Review of Science Underpinning the Assessment of the Ecological Condition of the Lower Balonne System

Report to the Queensland Government

Independent Scientific Review Panel

Prof Peter Cullen, Dr Richard Marchant and Dr Russell Mein

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Outline of Report

Executive Summary

This Review was commissioned by the Queensland Government to evaluate the science underpinning decisions relating to the management of water resources in the Lower Balonne.

There are important ecological assets in the Lower Balonne that need to be managed. These include the biota of the rivers and distributary channels of the Lower Balonne and their associated wetlands, the internationally recognized Narran lakes, the National Parks of the Culgoa floodplain and the Darling River itself. At the same time, there are significant economic and social benefits to the community from the irrigation developments of the Lower Balonne. The irrigation community itself recognizes the importance of protecting these natural areas and stated in their submission that significant degradation of the protected natural areas would be unacceptable to them (SmartRivers, 9/9/02 P1).

The challenge for Government is to use the best available science to ensure management provides a wetting regime appropriate to protect these important ecological assets, and yet provide the maximum amount of water for irrigation that is possible without causing significant degradation of the system.

The aquatic invertebrates in the rivers do not at present indicate evidence of human disturbance either moving downstream, or in comparison to adjacent catchments. The fish communities do show a trend downstream, but it is not yet possible to say conclusively that this is due to water management or to natural changes that can occur in a distributary system. It is important to note that the Lower Balonne has not yet experienced the impacts of potential diversions from existing infrastructure, and that there are likely to be significant lag times before ecological impacts become apparent.

The rivers and wetlands of the Lower Balonne system are presently in a reasonable ecological condition, but this condition is expected to deteriorate if the present capacity to extract water from the system should actually be exercised.

The water gauging and flow modelling capacity of NRM accord with accepted industry standards and are quite appropriate for the regional water planning being undertaken.

Management targets expressed as a function of mean annual flow (MAF) are neither suitable nor practicable for the Lower Balonne. The extreme year-to-year flow variation makes the estimation of MAF uncertain, even without measurement error; this would be exacerbated for compliance monitoring of MAF-linked targets. The Panel advocate using an event-based management approach tailored to meet the flow needs of downstream environments; its implementation would be achieved through scenario modelling to develop an event management policy.

The projected median annual flows in the Culgoa River and Narran River at the Border are 24% and 32% of simulated natural respectively (NRM Submission, P24). These, and other flow statistics, indicate that the flow attributes are highly modified from simulated natural.

Human activities have been having impacts on the ecology of the Lower Balonne since the various bifurcation weirs were constructed to divert water from the Culgoa to the various distributary channels to spread floodwaters across the floodplain. These diversions have seen

the Culgoa change from what was reported to be an almost permanent flowing stream to one that is now a flood pulse river like the distributary channels. This has obvious impact on restricting available fish habitat and refuges during dry periods. This situation will worsen when the current infrastructure is utilised to harvest water in the Lower Balonne.

Use of the current infrastructure to its full potential will result in the removal of small floods from the system and reduce medium floods to small floods. Extractions from larger floods, occurring on average every 10 years or so, will not have much impact. However, the Narran lakes would be expected to fill on average once in about seven years rather than once every two under pre development conditions. We agree with the contention that this will lead to significant long-term degradation of the Narran lakes as has been evident in other terminal wetland systems when their water supply is markedly reduced.

An interim finding by the Review Panel, to be reviewed once the ecological study of the Narran lakes is completed, is that the Narran lakes need to be flooded on average once every 3.5 years if its ecological values are to be maintained. This estimate is based on the NSW NP&WS submission that degradation will occur if volume and frequency of flooding is reduced below 60% of pre-development (Section 6.5).

The Panel recommends that the target of wetting on average every 3.5 years for the Narran lakes, and appropriate frequency for the two Culgoa National Parks, be achieved through close consultation with the community, given the need for a cooperative approach to manage the large number of extraction points and individuals involved. With the calibrated model now available this can be readily achieved and such consultations should be completed within a period of three months (Section 7.1).

It is likely that the reduced flooding frequency will lead to further changes in the vegetation of the Lower Balonne floodplain. Already pastoralists report a reduction in productivity due to reduced grass growth from reduced wetting, and we expect the area of floodplain trees of red gum, Coolibah and lignum will be reduced and these species replaced with grasslands. Two important National Parks, established to protect these vegetation communities, will be at risk, and it is important that further scientific work to assess their wetting needs be undertaken. This work should start immediately since it may take a period of five years to obtain useful results.

The Panel is of the view that it is possible to reduce these impacts to acceptable levels by careful management of floods that ensures the various wetland assets, including Narran lakes and the Culgoa National Parks receive appropriate wetting.

While flow is seen as the most important stress in this system, there are other factors that can affect the health of the Lower Balonne and need to be managed effectively. These include land use practices that affect runoff, the contaminant and sediment load. The weirs and dams installed to control flow also can block fish movement and cause other impacts. The construction of levees to isolate parts of the floodplain for agricultural development will also cause impacts on river health.

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Key Findings

ToR1 To review the Department's Integrated Quantity and Quality Model (IQQM) for the Condamine-Balonne Basin.

The Panel notes that there is general agreement that the St George gauge gives good estimates of flows into the Lower Balonne system, over the whole flow range. At this important site, event flow-rates and volumes are well defined for management purposes. Ratings for other (downstream) gauges are considered generally satisfactory (by accepted standards) in the low to medium flow ranges. While efforts should continue to be made to obtain the information needed for the higher range, this is not considered crucial for management targets based on flow events of most interest (Section 3.1).

The Panel concludes that the issues raised in respect to differences between 'predevelopment' and 'natural' flows need not be considered further (Section 3.2).

The Panel recommends that QNRM improve its documentation of the IQQM model and ensure community access to up-to-date documentation, possibly using its web-site, to address stakeholder needs (Section 3.3.1)

The Panel considers the performance of the IQQM on the Lower Balonne, as shown by the calibration and verification outputs, to be quite satisfactory; the results are consistent with the expected error bands for modelling of this type (Section 3.3.3).

The Panel believes that a display of the water balance for each event is important for the acceptance of the model as a tool for showing the impact of various management scenarios, and of great help in establishing a management plan for the Lower Balonne system (Section 3.4).

The Panel is of the view that the current IQQM model is an appropriate tool for evaluation of strategies to meet water management targets for the Lower Balonne. It supports the involvement of stakeholders in verification of the information used in the IQQM data files (Section 3.4).

The Panel believes that the DST model is an appropriate way to assess Type A water volumes and, to a lesser extent (because of limited data and area of coverage), the impacts of levees and further diversions on users downstream (Section 3.6).

TOR 2 – *To review the current ecological condition of the Lower-Balonne River system, including its floodplains and wetlands.*

The Panel notes that the river has not experienced a flow regime that will result from the extraction with the current levels of infrastructure development. It is therefore likely the present health of the Lower Balonne river system reflects extraction patterns from some period in the past (Section 6.2).

The Panel is of the view that from the sampling that has been undertaken to date there is no present evidence from the invertebrate faunal composition of stress increasing downstream of the Beardmore Dam or in comparison to adjacent rivers (Section 4.1.1).

The Panel finds that NRM's more recent sampling and analysis has not supported the preliminary interpretations made in the June 2000 Draft WAMP that the invertebrate fauna in the Lower Balonne downstream of the bifurcation was in a generally degraded state (Section 4.1.1).

The Panel believes that, because of the variations in water level, it is better to avoid quantitative comparisons of invertebrates and to rely simply on the frequency of occurrence of taxa which can be obtained with either method (Section 4.1.1).

Despite the limitations of the models, the O/E scores for the combined models give no indication of any downstream trends in invertebrate communities along the Lower Balonne (Section 4.1.1).

The Panel believes the invertebrate data, both the taxa present and the O/E scores from the AUSRIVAS models, does not presently provide evidence of degradation in river health. There are no trends obvious either down the Lower Balonne rivers or in comparison to other adjacent river systems (Section 4.1.1).

The Panel is of the view that attempts by NRM to model fish communities are not justified by the quantity of fish data that are currently available (Section 4.1.2).

The Panel accepts there is evidence that the composition of fish communities changes in a downstream direction but finds that the data is as yet insufficient to show whether this change is ecologically significant or whether it is caused by water development. We note however that the river has not yet seen the impacts of potential diversions, and that there are likely to be significant lag times before ecological impacts become apparent. The current monitoring design has a limited capacity to detect change and it is imperative that future sampling and interpretation be based on sound statistical principles.

The Panel notes the anecdotal evidence from several landholders that the reduced frequency of flooding of parts of the Lower Balonne floodplain has resulted in a reduction in agricultural productivity. The Panel is of the view that the agricultural productivity is likely to respond to reduced wetting before the deeper rooted tree communities are impacted. We have no direct scientific evidence as to the health of these tree communities (Section 4.2).

The Review Panel is of the view, that on the evidence before us, the Narran lakes are not yet showing signs of degradation (Section 4.3)

The Panel accepts that the Darling River is significantly degraded and that changes to flow regimes are one of a number of contributing factors (Section 4.4).

ToR4 To review the range of likely future ecological conditions and trends in the health of the Lower Balonne River system, including its floodplains and wetlands.

The Panel believes that the important floodplain vegetation that has been protected in National Parks in Queensland and in NSW is at risk due to decreased frequency and

duration of wetting due to the loss of medium sized floods. We believe these hydrological changes will lead to a loss of vigour and eventual replacement of these plant communities with grassland species (Section 5.1.1).

The Panel finds that the health of the river and distributary channels is likely to decrease with the flow changes that are expected. In particular the downstream pools that provide refuges for fish and other biota may become more restricted and water quality may deteriorate (Section 5.1.2).

The Panel anticipates changes in the Narran lakes will begin when the flows are altered to the extent now possible, and will continue to have increasingly obvious ecological impacts over the next forty years as has been the case in other terminal wetland systems such as the Macquarie marshes. We anticipate the Lakes will fill less frequently, causing longer dry periods leading to an encroachment of terrestrial vegetation to replace the aquatic vegetation and a reduction in the frequency of successful bird breeding events (Section 5.1.3).

The Panel notes that the possible level of water extraction in the Lower Balonne puts further flow related stress onto the already degraded upper Darling, but that these flow changes are mitigated downstream and they will be minor in the Lower Darling and the Murray. The ecological impacts of such changes are not known (Section 5.1.4).

The Panel supports the contention of the CRC for Freshwater Ecology that there will be significant long term degradation of the Lower Balonne floodplain and of the Narran lakes in particular once the system experiences the water extraction that is possible with the present infrastructure. We see a long period of decline, with the full impacts not necessarily being fully obvious within the 40-year time scale of this assessment, due to the background high flow variability (Section 5.1.5)

There has already been extensive loss of floodplain for agricultural development. The Panel is of the view that no further losses of floodplain should be allowed pending scientific studies demonstrating they will have no impacts on the health of the Lower Balonne system (Section 5.2.4).

The Panel is of the view that salinity is a potential problem for parts of the Lower Balonne, and that NRM and agencies need to act to investigate and manage it. There is significant salt in the landscape, but it appears not be uniformly distributed. It may be mobilized by rising groundwater that could arise from clearing of native vegetation, seepage from farm water storages or from excessive irrigation. We support ongoing assessment and management of this problem that we understand is occurring under the NAPSWQ (Section 5.4).

ToR 3 To review the current relevant scientific information in order to propose an ecological definition of the healthy working river applicable to the Lower Balonne context.

The Panel notes that the river has not experienced a flow regime that will result from the extraction with the current levels of infrastructure development. It is therefore likely the present health of the Lower Balonne river system reflects extraction patterns from some period in the past(Section 6.2).

The Panel accepts that it takes some time for a river and wetland system to exhibit the signs of stress from alterations to flow patterns, and so the present condition of the rivers and wetland may not reflect the present level of actual extractions experienced by the river to date (Section 6.2).

The Panel is of the view that the dominant consideration in the Lower Balonne system is to ensure the Narran lakes receives an appropriate flow regime to maintain the vegetation and bird communities. If this is achieved, the flow regime in the Narran River will be adequate to maintain the river and distributary channels in good condition (Section 6.4).

The Panel is concerned that the possible level of extraction will exacerbate damage to the Lower Balonne floodplain. We believe a loss of productivity in the grasslands is evident from landholder observation, and we anticipate a loss of the area supporting tree vegetation and its replacement with grassland over the longer time frame. Further studies are needed to identify wetting regimes that might avoid this possible decline (Section 6.4)

The Panel is of the view that the health of the Lower Balonne system and the interests of irrigators would be better served if a more appropriate measure of the required wetting regime than MAF was developed and used to guide management of water in the Lower Balonne (Section 6.5).

An interim finding by the Review Panel, to be reviewed once the ecological study of the Narran lakes is completed, is that the Narran lakes need to be flooded on average once every 3.5 years if its ecological values are to be maintained. This estimate is based on the NSW NP&WS submission that degradation will occur if volume and frequency of flooding is reduced below 60% of pre-development (Section 6.5).

ToR5 To review the reversibility or the lessening of the predicted trend in ecological condition outlined in 4.

The Panel believes that event-based targets should be adopted for water and environmental management in the Lower Balonne. A consideration of sampling errors alone indicates that targets linked to MAF should be avoided (Section 7.1).

The Panel recommends that the target of wetting on average every 3.5 years for the Narran lakes, and appropriate frequency for the two Culgoa National Parks, be achieved through close consultation with the community, given the need for a cooperative approach to manage the large number of extraction points and individuals involved. With the calibrated model now available this can be readily achieved and such consultations should be completed within a period of three months (Section 7.1).

The Panel notes that experiences elsewhere have shown that it is technically and politically much more difficult to restore degraded systems than to prevent degradation in the first place. We therefore urge a conservative approach with immediate action to provide the required wetting regime with ongoing monitoring and assessment (Section 7.1).

ToR6 To advise on river health monitoring and risk assessment frameworks for determining the future ecological condition of the Lower Balonne River system.

The Sustainable Rivers Audit of the MDBC is an appropriate base framework for monitoring, and is presently being tested and developed in the Condamine-Balonne. Additional indicators such as bird breeding events, fish breeding events, algal bloom incidence and vegetation communities need to be incorporated (Section 8.1).

The Panel is of the view that the proposed ecological study of the Narran lakes is important to the effective management of the Lower Balonne floodplain and should be undertaken without delay (Section 8.5).

In view of the importance of evaporation in the Lower Balonne, the Panel recommends that a specialist study be undertaken of the most accurate way to estimate evaporation from typical water storage's, and the means by which evaporation loss might be minimized (Section 8.5).

1. Introduction

1.1 Background to the Review

The Premier of Queensland, Mr Peter Beattie, commissioned this Independent Scientific Review following a meeting with irrigators in Dirranbandi in July 2002. At that meeting Mr Beattie announced plans to recover water from irrigators of the Lower Balonne for environmental reasons. The irrigators were concerned about the validity of some of the material on which this decision was based, and sought an independent review of the scientific work.

1.2 Terms of Reference

The Government agreed on the Terms of Reference for the Review with a Community Reference Group (CRG) [Appendix D] chaired by Mrs Leith Boully, and the Minister for Natural Resources Mr Stephen Robertson released these on 6th August 2002,

These Terms of Reference (ToR) are:

1. To review the Department of Natural Resources and Mines' Integrated Quantity and Quality Model (IQQM) for the Condamine-Balonne Basin.
2. To review the current ecological condition of the Lower Balonne River system, including its floodplains and wetlands.
3. To review the current relevant scientific information in order to propose an ecological definition of the healthy working river applicable to the Lower Balonne context.
4. To review the range of likely future ecological conditions and trends in the health of the Lower Balonne River system, including its floodplains and wetlands.
5. To review the reversibility or the lessening of the predicted trend in ecological condition outlined in Term of Reference 4.
6. To advise on river health monitoring and risk assessment frameworks for determining the future ecological condition of the Lower Balonne River system.

1.3 Conduct of the Review

The Review Panel advertised for submissions in "The Australian" and a range of regional newspapers between 24-30 August 2002, inviting submissions to the review. Some 16 submissions were received (listed in Appendix A) and a wide variety of supporting documentation made available to the Review Panel by the Department of Natural Resources and Mines (NRM) and by other interests.

The Panel conducted a two-day workshop in Brisbane on 18-19th September, followed by a two-day field visit. The Panel received verbal submissions from a number of those making written submissions, and held discussions with various interests. The CRG was present during this workshop, and given an opportunity to ask questions or make comments. The meeting was open to other observers.

The Panel had a one-day meeting in Melbourne, and developed a list of the issues of contention under the terms of Reference, and these were supplied to the CRG. The CRG agreed with the issues of contention, and stressed the particular importance to them of two of

the issues, relating to the accuracy of NRM flow measurements and to the identification of critical ecological assets and identification of the flow regimes required to maintain them. The Department of Natural Resources and Mines, in response to CRG requests put on a one-day workshop on the operation of the IQQM model on 28th October. Dr Mein attended this workshop which identified some further issues of concern to the community.

The Panel held a further one day workshop in Brisbane with the CRG on 29th October, primarily to explore the various data sets and interpretations relating to river health in the Lower Balonne rivers. This session was closed to observers for part of the day.

The CRG requested further exploration of the data held by the Department relating to pumping regimes, which are self-reported by irrigators, and other issues relevant to the IQQM modelling of the Lower Balonne. A meeting to address these was held on Thursday 14th November, and was attended by Dr Mein, members of the CRG, and representatives of NRM.

A draft report was issued to the CRG on 10th December and a final closed workshop held with the CRG on 13th December that provided feedback to the Panel. The Panel also sought additional comments from several scientists, including Dr Bruce Chessman, Dr Peter Gehrke, Dr Richard Kingsford and Assoc Prof Martin Thoms to ensure we had used their work in appropriate ways. Their assistance is acknowledged.

The Scientific Review Panel would like to express its appreciation to the staff of NRM, the CRG, and other interested parties who have made submissions and reports available to us. While there have been strongly expressed interests, all have strongly supported the need for the Panel to provide an independent assessment of all the material now available. This we have attempted to do.

1.4 Outline of Report

This report first outlines the ecological assets of the Lower Balonne that have been identified as worthy of management attention. It then considers the accuracy of stream gauging and modelling in the context of management of these ecological assets. The review then outlines what is known about the current condition of the assets, and the likely future of the assets under the possible levels of water extraction allowed by present infrastructure. The Report then determines the flow regimes needed to maintain the Narran lakes on the basis that this asset is regarded as internationally important and is seen as being at risk from current potential water extraction.

The Panel has reviewed the science put before us by those making submissions. We have not attempted to write a comprehensive account of the ecology of the Lower Balonne, so have not repeated much of the descriptive material put before us; the reader seeking such information should refer to the primary documents. Nor have we been in a position to undertake new research to help elucidate the challenges of the Lower Balonne; much is yet to be done, but that is outside the role given to the Panel.

2. Ecological Assets of the Lower Balonne

The Lower Balonne system downstream of Beardmore Dam can be described as a single channel (to Whyenbah), before breaking into a series of distributary channels across the

floodplain; some of the latter end in the Darling River while others, such as the Narran R, end in important terminal wetlands.

Irrigation has been developed on this floodplain by pumping from the rivers and distributary channels during flood periods, and diverting flood flows; the collected water is held in extensive shallow dams for later irrigation of crops, mainly cotton. There has been significant investment in irrigation infrastructure on the floodplain (including recent deepening of storages to reduce evaporation); various submissions pointed out the economic and social benefits that have arisen to the community from this investment.

There are important ecological assets that include the:

- biota of the rivers and distributary channels, and wetlands of the Lower Balonne
- internationally recognized Narran lakes
- National Parks of the Culgoa floodplain
- biota of the Darling River

Appendix B has more details of some of these.

The Balonne River Floodplain wetlands in Queensland represent a significant aggregation of wetlands on the floodplain. These systems range from ephemeral wetlands to permanent billabongs. The actual area of the wetlands is in the order of several hundred hectares spread over approximately 24,000 ha of floodplain.

The irrigation community recognizes the importance of protecting these natural areas and stated in their submission that significant degradation of the protected natural areas would be unacceptable to them (SmartRivers, 9/9/02 P1).

The annual flow volumes are dominated by large but infrequent flow events, and are amongst the more variable found in Australia. Because of this year-to-year variability, it is not possible to specify the annual mean flow with great precision, even with the 80 years of streamflow data that now exist. The terrain is relatively flat, and flow spreads into a number of streams. Overbank flow is common, even for low to medium sized flow events, and a significant volume of water (typically 25-30% of overflow events) infiltrates or evaporates on the floodplain and does not return to downstream rivers.

The issues of the Lower Balonne relate to the present and likely future impacts of irrigation developments on the health of the Lower Balonne floodplain system. The issues relating to the accuracy of river flow measurement and the validity of modelling of flows can only be considered in the light of what precision is needed to address the ecological issues of concern.

Table 1. Ecological Flood Thresholds for Balonne Floodplain System
(from Whittington et al CRC for Freshwater Ecology, 2002)

Flow Threshold at St George ML/D	Average Return Interval*	Ecological relevance
25,000	~ 1.6 years	Water begins to moves out of the main channel and into the secondary channel network of the floodplain
45,000	~ 3 years	Three of the main floodplain vegetation communities (Coolibah open woodlands, Lignum and Riparian Forests) have at least 50 percent of their total area wetted.
60,000	~ 3.6 years	The majority of the main flow paths across the floodplain are full. This area includes the large stands of Coolibah Open Woodland, Riparian Forest and Lignum communities on the floodplain.
70,000	~ 4 years	There is a significant increase in the diversity of floodplain plant communities. Four of the main vegetation communities have at least 40 percent of their total area wetted plus another 3 vegetation communities have at least 15-20 percent of their total area wetted. At this flow at least 40 percent of the total floodplain is inundated.
120,000	~ 8 years	Approximately 70 % of the total floodplain area between St George and the border is inundated and further increases in flow result proportionally larger increases in the depth of flow across the floodplain rather than floodplain area inundated.

* based on historic flows at St George

3. Measuring and Modelling of Flow (ToR1)

ToR1 ***To review the Department's Integrated Quantity and Quality Model (IQQM) for the Condamine-Balonne Basin.***

The review should examine and report on the certainty of the IQQM flow outputs within the Lower Balonne area, including comment on the adequacy of the hydrographic ground truthing, and draw on the Pells, Sullivan and Meynink "Review of Condamine-Balonne River Hydrology" (2 May 2001) including reporting on how its recommendations have been implemented. The review should also assess the Decision Support Tool developed by SMEC under the auspices of the Lower Balonne Floodplain Management Framework as a tool for assessing hydrological impacts of water resource development. The review should clearly separate the historical rates of actual extraction from potential future rates of extraction.

The main submissions relating to ToR1 were from NRM and SmartRivers, both accompanied by a number of supporting documents. The key points they raise are addressed in the sub-sections below. Because the CRG regarded the accuracy of flow measurement as 'critical to the Review', it is considered first.

3.1 Errors in Flow Measurement

The accuracy of measurement of flow is an important issue in the Condamine-Balonne. Both the IQQM model and the SMEC Decision Support Tool are calibrated with observed data; hence errors in observations will result in errors in calibrated model parameters, and thus modelled flows in the Lower Balonne system.

Another issue relates to the use of flow targets based on the mean annual flow (MAF) at the St George gauge. The precision of the estimate of the MAF itself is of great relevance to the stakeholders of the Lower Balonne.

Two types of error are relevant - sampling error and measurement error.

Sampling error arises from the fact that the gauged period of record is but a 'sample' of the longer-term behaviour of the river; the longer the period of observations, the more confident one can be that it represents the range of flows that are possible. Sampling error is of particular importance in determining the precision of estimation of measures like Mean Annual Flows (MAF) for rivers with large variations in annual flow.

For example, the MAF to Beardmore Dam over the period 1971 to 2001 is 1470 GL, with observed yearly totals in this period ranging from 8 to 440 percent of this. The standard deviation of annual flows (a statistical measure of year to year variability) is 1410 GL. The ratio of the standard deviation and the mean, the coefficient of variation (CV), is thus 0.96, a very high figure even by Australian standards. Statistically speaking, with a CV of 0.96, about 250 years of measured data would be needed to be 90% sure that the mean is specified to within ± 10%! A hundred years would be needed to be 67% certain. The gauged period of record at St George is 80 years.

An immediate conclusion is that a target linked to MAF (eg 46% of the MAF at St George to reach the border) is impractical for the management of rivers as variable as the Lower Balonne, because of the inherent uncertainties.

Measurement error relates to the accuracy of flow determination at the gauged site itself. The Institution of Engineers, Australia's 'Australian Rainfall and Runoff' (the accepted standard for flood estimation in Australia) notes the particular difficulties in flood flow measurements in this country. It states the 'the accuracy of high floods at most stations is probably not much better than ± 25% at best, and in many cases much worse, especially in northern Australia'. For total event runoff (as opposed to flood peaks), gauging stations rated as 'good' will give flood volumes with an accuracy of ±10%; stations rated as 'poor' will give ±25%.

The point to be made is that gauged accuracies for flow volumes are never going to be better than ± 10% in systems like the Lower Balonne; for large floods, the error range can be expected to be much larger (± 25% and more).

The Panel has not made direct assessment of the quality rating of stream-gauging stations in the Lower Balonne in this Review. However, several submissions and documents include examination of the many gauged sites in the river system. Generally speaking, their findings are consistent with what one would expect in such variable flows and terrain as pertain to the

region; ie. reasonably good ratings in the low to medium range, with problems in defining high flows at some stations.

The PSM review, for instance, concluded that 'quality of rating curves to estimate total flow in the river was considered to be good with two notable problem areas'.In the Lower Balonne, these were the Woolerbilla station on the Culgoa River, and Briarie Creek at Hebel-Woolerbilla Road. They mention the issue of ungauged high flows at these sites, and recommend hydraulic modelling to help rectify this. The SKM 2002 Report for SmartRivers raises similar issues of accuracy, especially for gauges in the lower region, but claim bias (underestimation) of volumes of high flow events due to portions of the flow by-passing some of the gauge sites.

The difficulty of measurement of discharge in the distributary channels during large floods adds further weight to the Panel's recommendation not to use targets linked to MAF. Such large events are not greatly affected by storage extractions, but can have a significant impact on the magnitude of the MAF. [Event-based management has been advocated in a number of submissions to this Review, a strategy endorsed by the Panel for a number of reasons, including the practicability of measurement and compliance monitoring.]

The Panel notes that there is general agreement that the St George gauge gives good estimates of flows into the Lower Balonne system, over the whole flow range. At this important site, event flow-rates and volumes are well defined for management purposes. Ratings for other (downstream) gauges are considered generally satisfactory (by accepted standards) in the low to medium flow ranges. While efforts should continue to be made to obtain the information needed for the higher range, this is not considered crucial for management targets based on flow events of most interest.

3.2 'Pre-development' vs 'natural' flows

Submissions from SmartRivers to the Panel raised the issue of changes in the flow regime of the Condamine-Balonne River caused by tree clearing in its catchment between 1840 and 1920. Given that gauged records began at St George immediately after this period, the question of the magnitude of any difference between natural flows (pre 1920) and the pre-development flows (1990) seems hardly relevant now.

Scientifically, the evidence for increased flows after changing forest cover to pasture/crops has been greatly clarified in recent years. Probably the best work has been that of Dr Zhang and others at CSIRO Land and Water (eg. Zhang et al, 1999; Bradford et al, 2001). This group has tested rainfall-runoff relationships based on observed response data, extended using knowledge of hydrologic processes, on catchments worldwide. The data set included Australian catchments covering a wide range of climate. Their findings show that the impact of changed vegetation cover is greatly dependent on average annual rainfall, and annual actual evaporation, for the catchment in question. Of particular relevance is that the impact of the change from forest to grass is negligible when the mean catchment rainfall is less than about 500 mm/y, a circumstance which applies to the Condamine-Balonne. A recent study by Finlayson et al. (2001) of the Comet River, a large catchment immediately to the north of the Condamine-Balonne, could not detect changes in runoff due to large-scale clearing, and thus supports the CSIRO findings.

The Panel concludes that the issues raised in respect to differences between 'predevelopment' and 'natural' flows need not be considered further.

3.3 Validity and accuracy of the IQQM Model

The main emphasis of ToR1 concerns the IQQM model. This section deals with the model and its purpose, its calibration on the Condamine-Balonne, and the expected errors in its application.

3.3.1 The IQQM model

The IQQM (Integrated Quantity and Quality Model) is a hydrologic modelling tool developed by the NSW Department of Land and Water Conservation, with collaboration from the Queensland Department of Natural Resources and Mines. Its prime purpose is to simulate the impacts of water resource management strategies on flows, so the evaluation of the impacts of various water diversion scenarios in the Lower Balonne is within its intended uses. IQQM has been subject to widespread and rigorous scientific reviews, and is well regarded for its capability to estimate flow volumes.

The model provides a daily simulation of water flows by representing river systems and flow paths using a series of nodes and links. The nodes represent points of significance for representation of the particular river system (eg gauging stations, diversion sites, stream junctions, etc), the links simulate flow paths and stream characteristics. The model includes a large number of routines to simulate different types of diversions, and so is very flexible in its range of application. Output from the model includes simulated hydrographs, and a wide range of flow analyses such as histograms and flow duration curves.

An issue raised in this Review related to the adequacy of IQQM documentation. In a model under active review and development, the work in keeping the IQQM manual up to date (and accessible) has clearly not been given priority. The Panel notes that this issue is important for stakeholders who need to know:

- what version of the model was used for each simulation run
- what changes have been made to the model in each revised version
- the impact of each revision on the modelled flows

The Panel recommends that NRM improve its documentation of the IQQM model and ensure community access to up-to-date documentation, possibly using its web-site, to address stakeholder needs.

3.3.2 Application of IQQM to the Lower Balonne

Application of IQQM to a specific catchment involves two steps – calibration / verification, and scenario simulation.

There have been a number of revisions to the IQQM representation of the Lower Balonne since the first application for the draft Water Allocation Management Plan released in June 2000. A thorough review by Pells Sullivan Meynink (Brisbane consultants) dated June 2001 listed 62 recommendations to address concerns with the modelling. The NRM, in its submission, report that virtually all of these recommendations have been addressed, although

some points of contention remain. One of these is the estimation of evaporation, which is a major issue on the Condamine-Balonne catchment. This is considered further under ToR6.

3.3.3 Calibration/verification of IQQM

Calibration of IQQM involves running the model and comparing its outputs with flows recorded at gauging stations. Changes in parameters are made to get the best 'fit' of the model at the sites where the flows are measured. The changes can include adding overland flow paths and/or flow 'sinks' to improve the water balance and/or incorporate local knowledge of flood behaviour. Calibration for the Lower Balonne was for the period 1974-1988. Verification to test the model was done by simulating flows for a different period of data record (1991-2000). In both cases, historical flows and storage records were used.

The Panel notes that the revised version of IQQM (incorporating virtually all of the changes recommended by PSM) was the one used for the Calibration Reports supplied to the Review.

The Panel considers the performance of the IQQM on the Lower Balonne, as shown by the calibration and verification simulations, to be quite satisfactory; the results are consistent with the expected error bands for modelling of this type.

Typically errors are largest for the higher peak flows (say 30-40%), less for event volumes (say 15-25%), less for annual volumes (say 10-15 %), and less again for the differences between scenarios for the same period of record (say 5 – 10%).

3.4 Use of IQQM for evaluation of management scenarios

The material submitted to the Panel by NRM presented the results from the calibrated IQQM for two management scenarios. These were:

(i) the 'pre-development' case, in which the river flows downstream of the St George gauge have been simulated for the period 1922-1995, assuming no off-stream storages,

(ii) the 'existing' case, in which the current diversion capabilities (rates and quantities) are included at appropriate nodes in the IQQM representation of the Lower Balonne. The simulation was again run using the 1922-1995 data to estimate the potential impact of water extractions from the river system.

The comparability of the two scenarios is masked somewhat by the change in inputs for the Lower Balonne for (ii) due to increased diversions upstream of the Beardmore Dam. The workshop held in Brisbane on 14 November 2002 requested that the IQQM model be run without these increased diversions to assist interpretation.

A further request at the 14 November workshop was for a display of the aggregated components of the water balance for each event. For instance, the total diversion to storage would be shown for each flood flow, but with the facility available for users to examine the sub-components of this.

The calibrated IQQM provides the means to assess the impact of a range of potential future extraction scenarios to be simulated and assessed. Clearly, in such exercises, the accuracy of

representation of the major storage and diversion infrastructure in the system is important for credibility of the modelled scenarios.

At the request of the CRG, a process to check the data being input to the IQQM model was begun in mid-November 2002. The Panel supports this initiative.

The Panel believes that a display of the water balance for each event is important for the acceptance of the model as a tool for showing the impact of various management scenarios, and of great help in establishing a management plan for the Lower Balonne system.

The Panel is of the view that the current IQQM model is an appropriate tool for evaluation of strategies to meet water management targets for the Lower Balonne. It supports the involvement of stakeholders in verification of the information used in the IQQM data files.

3.5 The SMEC Floodplain Model (DST)

The Lower Balonne river system is characterized by a good deal of over-bank flow during flood events, even for relatively small ones. 'Losses' from this flow due to infiltration and depression storage are considerable, and need to be accounted for in simulation of the system.

The SMEC DST (Decision Support Tool) is a hydrologic model designed to simulate the extent of inundation, and hence the amount and location of water 'lost' from a single flow event. Its purpose is to:

- estimate the amount of Type A water attributable for each landholder for each event (the water 'saved' by levees around areas which would be otherwise flooded),
- estimate the impact of further levees and diversions on flow volumes (not depths) generally.

The method used for flow routing in the SMEC model is necessarily a simplified one, and assumes flow is in one direction (parallel to streams). As with most hydrologic models, the DST model needs data for calibration of its parameters. For this, in addition to gauged flow data, the DST model uses observed areas of inundation during events to assist with parameter adjustment. Hence the accuracy of ground level data, and the timing of aerial photographic data, are both important factors in the accuracy obtainable.

Errors documented for the calibration runs are consistent with those expected in hydrologic models of this type (see Section 3.3.3 above). They indicate that a reasonable estimate of Type A water can be made with DST for events within the calibrated range. The Panel notes, however, that the impacts of flow diversions on the floodplain on flows downstream will be less well estimated, due to the limitations of the one-dimensional flow assumption (ie not representing cross flows) and the areal extent of modelled area (eg not covering the NSW component).

The DST model (its assumptions, limitations, and modelling performance) is well documented in the two reports provided to the Panel. The Panel were also impressed with the visual displays afforded the operator when the model is run. It is a good example of the benefits of stakeholder input during development.

3.6 Relationship of the DST model to IQQM

The Panel notes that the IQQM and DST models have completely different objectives; neither model will replace the other. Whereas IQQM aims to quantify the impacts of different management scenarios on downstream flows over a period of time (1922-1995), the purpose of the DST model is to simulate inundated areas for individual events (to compute Type A water) in real time.

The models are complementary in that they use the same node structure for the Lower Balonne. Hence, it would be possible to cross-link DST with IQQM at each node to simulate Type A water for different diversion scenarios over a period of time; this has not yet been done.

The Panel believes that the DST model is an appropriate way to assess Type A water volumes and, to a lesser extent (because of limited data and area of coverage), the impacts of levees and further diversions on users downstream.

4. Assessments of Ecological Condition (ToR2)

TOR 2 – *To review the current ecological condition of the Lower-Balonne River system, including its floodplains and wetlands.*

"The review should focus on canvassing and reporting on existing ecological assessments of the Lower Balonne River system and associated habitats that have been undertaken by departmental and other scientists in recent years. The review must provide a summary statement of the current ecological condition of the system and comment on the methodology used and the adequacy of the data set used to support this statement. Sources of current historical and potential future impact on the system should be identified and their probable relative significance ranked."

Data on the macroinvertebrates and fish of the river and distributary channels from studies conducted by NRM and environmental consultants engaged by the irrigators were made available to the Panel, and we have undertaken our own analysis of the raw data as appropriate. Additional data for the floodplains on waterbirds and their breeding in the Narran Lakes were obtained from reports of other studies provided to the Panel. The material required to address the last sentence of the expanded ToR – 'sources of current historical ….' - is provided in Chapter 8.

4.1 Rivers and Channels of the Floodplain

4.1.1 Macroinvertebrates

Sampling of the Lower Balonne by Sinclair Knight Merz (SKM) in June 2000 and November 2001 and subsequently by Ecology Management (EM) in May 2002 reveals an invertebrate fauna that is low in diversity but with a composition typical of other western flowing rivers in NSW. Sampling by NRM in 2001 and 2002 shows a similar picture. The NSW EPA has undertaken some sampling of the Lower Balonne in northern NSW before it enters the Barwon River, and the invertebrate fauna in this region is essentially indistinguishable from that further upstream.

A total of 62 taxa (nearly all at the family level of identification) has been found by both groups (NRM and SKM/EM) using appropriate sampling techniques. Many of the frequently occurring taxa are either mobile or widely dispersed in such inland rivers. Only about 11 of the 62 taxa are relatively less mobile and are therefore more useful for assessing conditions at a specific site. These include several mayfly and caddisfly families that are generally confined to the benthic habitat and often considered more sensitive to human disturbances. Several families from this group of 11 are widespread in the Lower Balonne (Caenid and Baetid mayflies and Palaemonid prawns) suggesting that the distribution of invertebrate fauna in this region does not presently show evidence of substantial river degradation. If such degradation were present then these last groups in particular would not be widespread.

The SKM data show consistent differences in faunal composition between November 2001 and June 2002 and that samples from the floodplain channels are somewhat different from those taken in the river channels. This sort of variation is commonly encountered in other studies and gives confidence that the sampling is sufficiently sensitive to respond to these expected temporal and spatial patterns of variation. It also reinforces the need to base management decision on more than one data set that is all that appeared to be available to the TAP preparing the June 2000 Draft WAMP.

The SKM data also show that invertebrate composition at the four control sites (two each on the adjacent Warrego and Moonie Rivers) was not noticeably different from that found in the Lower Balonne and that no trend was evident of degradation increasing downstream from St George. Further sampling of riverine sites only (floodplain sites were dry) by EM in May 2002 revealed much the same diversity of taxa, but no comparison of composition with that found previously was undertaken.

SKM also conducted a smaller scale study of 12 sites within Cubbie Station in April and November 2001. Few differences in invertebrate composition were found between the April and November samples and again no downstream trend in these communities was apparent. The number of taxa increased somewhat in November and this was attributed to a concentration of the fauna as the waterholes sampled dried out.

The Panel is of the view that from the sampling that has been undertaken to date there is no present evidence from the invertebrate faunal composition of stress increasing downstream of the Beardmore Dam or in comparison to adjacent rivers.

Earlier samples from sites in the Lower Balonne, taken in 1998 and before by NRM were interpreted as showing general degradation of the invertebrate fauna particularly at three sites downstream of the first bifurcation. However, these samples were taken either during a receding flood, contrary to standard sampling protocols, or from habitats that naturally appeared to sustain very few species. They were also analysed using first generation predictive models (Choy and Marshall, 1998) which have subsequently been refined.

The Panel finds that NRM's more recent sampling and analysis has not supported the preliminary interpretations made in the June 2000 Draft WAMP that the invertebrate fauna in the Lower Balonne downstream of the bifurcation was in a generally degraded state.

It is unfortunate that the Technical Advisory Panel made these preliminary conclusions with such limited data available to them in 1999. NRM is advised to be more strategic in its

collection of ecological data so that necessary information is available when needed for water resource planning.

In November 2001, SKM adopted a different sampling protocol for invertebrates from that used previously and that used by NRM. This new technique with edge sampling using a surber sampler generally captures a greater number of the available taxa at an individual site than a single sweep sample (the standard technique). This enables result to be expressed quantitatively (and with a measure of variability) thus facilitating comparisons of the abundance of common taxa.

Differences between sites in composition were however evident with both techniques and it is not clear that any greater discrimination was obtained with the new technique. All analyses so far have been based on only the presence or absence of taxa, which seems appropriate given the great variability in water levels in the channels. Such variation in water level makes it difficult to interpret changes in abundance of taxa. Differences could be due to dilution or concentration of a fixed population as water levels fluctuate or it could be the result of a real change in the total population or it could result from both mechanisms acting simultaneously.

Comparisons of invertebrate composition at a range of sites showed no differences coinciding with the use of the two sampling methods and thus the supposed advantages of the surber sampler were probably not great.

The Panel believes that, because of the variations in water level, it is better to avoid quantitative comparisons of invertebrates and to rely simply on the frequency of occurrence of taxa which can be obtained with either method.

Another approach to interpreting the macroinvertebrate data is to subject the data to the Queensland AUSRIVAS regional models for two riverine habitats: edge habitats and the sandy or silty beds of pools. These models compare the fauna observed at a site with that expected to occur at the site in the absence of any disturbance. The AUSRIVAS model using environmental characteristics of the site predicts the expected fauna. These models have been developed over the last few years by University of Canberra and applied by NRM as part of a national approach to assessing river health.

The observed number of taxa versus expected number (O/E scores) for the edge habitat indicated that the fauna at the majority of sites was indistinguishable from that expected at undisturbed (or reference) sites (O/E > 0.84): three sites out of 14 were in band B (O/E < 0.84). Pools were more degraded with only one site out of 11 in reference condition. These results are for combined season models (combination of samples taken in spring and autumn) which have 16-17 expected taxa at the Lower Balonne sites. These numbers of expected taxa are at the lower limit of reliability for such predictive models. The single season models for both habitats have fewer expected taxa (4-8 for the pools and 9-11 for the edges). These are very low numbers for predictive models of this nature, making this approach less reliable. If one or two taxa are accidentally missed then the O/E ratio could vary by more than 10% when expected numbers are so low. This is an inevitable consequence of attempting to model the presence or absence with so few taxa.

Despite the limitations of the models, the O/E scores for the combined models give no indication of any downstream trends in invertebrate communities along the Lower Balonne

However, the O/E scores for the pools are generally lower than those for the edges, and it is not clear why this is so. At this stage it is premature to read too much into the pool scores. NRM believe that more experience needs to be gained with the pool models in particular before confident interpretation can be made.

Additional AUSRIVAS assessments from 11 sites on the Lower Balonne but in northern NSW (sampled by NSW EPA) give a similar picture. Only the edge habitat was sampled and 10 of the sites were indistinguishable from reference condition.

The Panel believes the invertebrate data, both the taxa present and the O/E scores from the AUSRIVAS models do not presently provide evidence of degradation in river health. There are no trends obvious either down the Lower Balonne rivers or in comparison to other adjacent river systems.

4.1.2 Fish

Fish, being a high level consumer, are an important and widely used indicator of ecosystem health. A number of measures are commonly used, including numbers of species, numbers of individuals and biomass of fish. It is also worthwhile to consider habitat issues that include consideration of refugia, flow rates, flow levels and instream woody debris. A variety of statistical approaches are used to interpret these data

There are difficulties with sampling fish in these systems, and real difficulties in developing experimental designs that will enable differences to be identified. It is important that these efforts continue and attempts are made to overcome some of the present shortcomings.

Fish sampling by both SKM/EM and NRM has shown that a community of about 12 species exists in the Lower Balonne and at sites in the adjacent Warrego and Moonie Rivers. This community consists of three exotic species (Carp, Goldfish and Gambusia) and nine native species. A number of these species have very patchy distributions. Bony Herring and Golden Perch, which occur at nearly all sites, dominate the native species; Carp dominates the exotics.

a. Differences to Adjacent Catchments

Neither the SKM nor the NRM data show any clear differences in fish abundance, or species diversity between the Lower Balonne and the adjacent Warrego and Moonie rivers. These adjacent rivers that do not have extensive water development, have somewhat different elevations and somewhat drier catchments so care must be used in considering them as reference catchments by which to measure disturbance.

b. Downstream Trends

Examination of the SKM data by ordination (particularly their data for November 2001) shows no trends in the species composition of the various sites. Most sites in the Lower Balonne have a very similar fish composition. Downstream trends in diversity along the Lower Balonne floodplain are, if present at all, not obvious on these ordinations. The data do give some indication that fish communities from the floodplain channels are slightly different to those from the riverine channels. As with the macroinvertebrate communities, where a similar pattern was evident, such changes are not unexpected.

NRM data, on the other hand, do show trends that indicate fewer native fish species and fewer individuals occur in the Lower Balonne (below the first bifurcation) than occur further upstream (Supplementary Submission). Whether this is an early sign of degradation due to water development, or a natural feature of a distributary system is as yet unclear. It is possible that the distributary system downstream of the first bifurcation offers a somewhat different habitat compared with the single river channel upstream (the mid Balonne). Each distributary channel may support fewer species than the single upstream channel simply because each is narrower and shallower and thus provides a smaller range of habitats and resources.

NRM have analysed statistically the number of fish species in an attempt to identify the cause of this observed trend. They conclude that after making allowances for a natural decline in species number down the Balonne, the numbers observed downstream of the first bifurcation are lower than would be expected. The evidence for a decline in species number, down the whole catchment, is convincing. However, the evidence for a greater than expected decline in numbers of species in the section downstream of the first bifurcation is equivocal. The Panel has itself carried out statistical analysis which shows that there are no significant differences in number of species between sites upstream (Kurray, Mooramanna, Whyenbah) and downstream of the bifurcation. Any trends thus appear to be suggestive rather than conclusive, but they certainly warrant ongoing investigation.

c. Modelling of the Expected Numbers of Native Fish Species

The number of species of native fish expected at a site was modelled by NRM (Original Submission) using various statistical procedures. The models were created from data on the distribution of 13 species from 15 reference sites in the Macintyre, Condamine–Balonne, Warrego and Paroo catchments. Such modelling exercises generally require data from a minimum of 30 –50 reference sites. In addition the total species pool (13) is so small that ratios of the number of species observed versus the number expected (O/E) are subject to chance errors.

Multivariate analysis by NRM of the fish communities at the 15 sites demonstrated that 6-8 species of native fish were expected at a site depending on altitude in the catchment. The expected numbers derived from the statistical modelling exercise differed usually by 1-2 extra species. Given the low number of species in total, such differences probably mean little.

If we accept that the expected numbers of species from the models are essentially equivalent to those estimated from the multivariate analysis, then it is possible to calculate O/E ratios using modelled data on E for 34 sites in the Condamine–Balonne catchment. NRM argue these data show a decline in the O/E ratio below the first bifurcation at the top of the floodplain (Site 15). However, when these ratios are examined by simply plotting the O/E score against the sites ordered from highest in the catchment to lowest (Fig.1) such trends are not readily apparent. The most obvious pattern is that the ratios are somewhat more variable upstream than they are downstream with perhaps the exception of the lowest site (Site 34, Culgoa River at Weilmoringle), which appears to have a limited fish community. The lower floodplain begins at Site 15 and it would be hard to argue from Fig.1 that the O/E scores are obviously reduced downstream of that site. (Some of the data in Fig.1 are overestimates according to NRM; their presence is unlikely to alter the conclusion just given.)

The Panel is of the view that attempts by NRM to model fish communities are not justified by the quantity of fish data that are currently available.

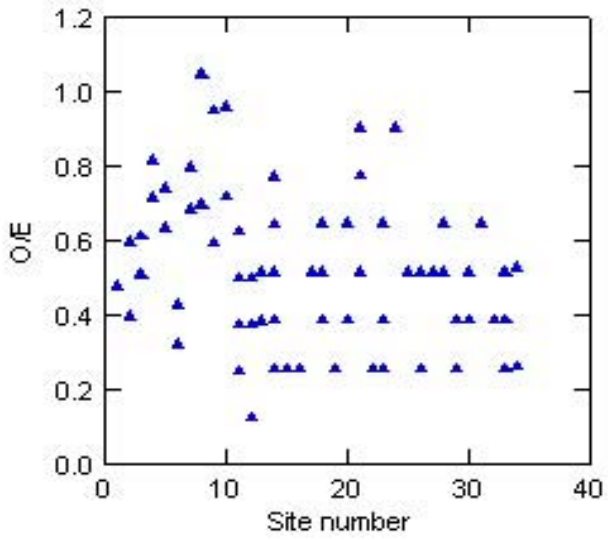

Fig.1 O/E scores versus site number for sites in the Condamine Balonne catchment. Sites are ordered from upstream (1) to downstream (34).

d. Analysis of NRM fish composition data

In their Supplementary submission NRM analyse the composition of fish communities at three groups of sites: mid Balonne, Lower Balonne and lower Warrego. Their ordination plots do not demonstrate obvious discrimination amongst the three groups, but they do show trends in the numbers of native species or numbers of individuals of native species: the highest values for these two variables occur in the mid Balonne and lower Warrego sites. Additional analysis (by the Panel) indicates that the sites in the mid Balonne are somewhat different in composition to those in the Lower Balonne and the lower Warrego. The latter two groups are, however, similar in composition. Thus there may be some change in composition and diversity along the Balonne. It is tempting to attribute this to the water harvesting developments on the floodplain downstream of the first bifurcation. However, no such developments occur on the lower Warrego, whose fish communities are similar to those in the Lower Balonne, and it would thus be rash to conclude that any changes in fish communities are unequivocally due to water harvesting.

The NRM analyses also note that two native species (Freshwater Catfish and Silver Perch) are much less frequently encountered in the Lower Balonne compared with the Warrego and the mid Balonne. Both these species seem to have undergone declines in abundance throughout the Murray Darling Basin and it is suggested that they are good indicators of stress resulting from human disturbances to the riverine ecosystem. NRM also points out that the introduced Goldfish is most abundant in the Lower Balonne.

These observations may indicate that human disturbance is beginning to affect fish in the Lower Balonne but that such disturbances are not yet severe or that they take some time

before they become evident at the level of fish community composition. NRM argue there will be a lag effect in the response of the fish fauna to floodplain developments, and the Panel agrees this is likely.

The Panel accepts there is evidence that the composition of fish communities changes in a downstream direction but finds that the data are as yet insufficient to show whether this change is ecologically significant or whether it is caused by water development. We note however that the river has not yet seen the impacts of potential diversions, and that there are likely to be significant lag times before ecological impacts become apparent. The current monitoring design has a limited capacity to detect change and it is imperative that future sampling and interpretation be based on sound statistical principles.

e. Habitat Issues

Human activities have been having impacts on the ecology of the Lower Balonne since the various bifurcation weirs were constructed to divert water from the Culgoa to the various distributary channels to spread floodwaters across the floodplain. These diversions have seen the Culgoa change from what was reported to be an almost permanent flowing stream to one that is now a flood pulse river like the distributary channels. This has obvious impact on restricting available fish habitat and refuges during dry periods. This situation will worsen when the current infrastructure is utilised to harvest water in the Lower Balonne.

f. Management Issues

NRM needs to be clear about its management objectives with regard to fish in the Lower Balonne. The local community values the recreational fishing available in local water bodies, and so they are concerned about the abundance of fish, and their productivity. The State also has concerns about biodiversity, and so the number of native species is an important indicator. Both abundance and species richness depend on the aquatic habitat available to fish, and this is largely a function of the flow management strategies adopted by the Department. Habitat is also a function of woody debris in channels, riparian communities and blockages to fish movement by weirs and structures.

Diverting water from the Lower Balonne for irrigation will reduce the volumes flowing in the downstream reaches of the rivers, and may reduce the period that such channels see flow. Both of these factors will reduce available fish habitat, leading to a reduction in the numbers and diversity of fish.

g. Science Issues

Fish are an important indicator of the health of the Lower Balonne, but there are a number of factors that affect their distribution and abundance. We commend NRM for the effort it has put into the fish work. We suggest that the complexity of this issue warrants higher level statistical and design advice to develop studies that will have the discrimination to separate out the various factors that might drive change in the Lower Balonne system. It is also important to appreciate that one of the major quality control devices in science is the publication process, which subjects work to technical refereeing and makes it available to the wider scientific community to comment upon. NRM is advised to ensure all its scientific work is published in the scientific literature on a timely basis to provide this quality assurance.

4.2 Floodplain Communities

The ecological assets of the Lower Balonne floodplain are described in Appendix B. The importance of the vegetation communities have been recognised by the declaration of two National Parks that straddle the border and aim to protect the Coolibah, red gum and lignum communities, as well as the wetlands of the floodplain.

These plant communities have developed in response to the wetting cycles they experience, and this is predominantly due to flood wetting rather than local rainfall. Coolibah communities seem dependant on flooding rather than local rainfall for regeneration, but they are a long lived species and may persist with infrequent flooding. According to Roberts and Marston (2000) Coolibahs in particular are tolerant of long periods without floods and on the Gwydir in NSW only receive floods once in every 10 – 20 years on average. Red gums appear to be more reliant on frequent flooding. Moreover, it can be seen that in areas that naturally receive less flooding the plant communities are dominated by grasslands and other species rather than the woody species that dominate the more wetted areas.

We received no submissions relating to the present health of these floodplain communities

There is also extensive pastoral activity on the downstream floodplains, and various landholders submitted that the reduced frequency of flooding of their properties has impacted on the carrying capacity and hence profitability of their land (Hagarty and Betts written submissions). No detailed assessment has been made of these claims, but they are supported by work of Ogden and Thoms (2002) showing reduction in soil productivity with reduced wetting frequency

The Panel notes the anecdotal evidence from several landholders that the reduced frequency of flooding of parts of the Lower Balonne floodplain has resulted in a reduction in agricultural productivity. The Panel is of the view that the agricultural productivity is likely to respond to reduced wetting before the deeper rooted tree communities are impacted. We have no direct scientific evidence as to the health of these tree communities.

4.3 Narran Lakes

There is substantial documentation relating to the ecological significance of the Narran lakes that have been listed as Ramsar wetlands. They are one of a small number of important bird breeding areas in Australia. They are nationally and regionally important.

4.3.1 Waterbirds

A recent review of the ecological features of the Narran Lakes by the CRC for Freshwater Ecology indicates that 65 species of waterbirds are known from this system of which 46 have been recorded as breeding during the last decade. In 1996 one of the biggest recent breeding events occurred with 22 species and at least 200,000 waterbirds breeding, the majority of which were species of ibis. All breeding events are associated with floods, which inundate the lakes and some of the surrounding floodplain. The birds make use of the wetlands when they are flooded as both breeding grounds and feeding grounds. Ibis for instance are able to capture aquatic invertebrates and probably small fish and amphibians in shallow areas of the wetlands.

It is not possible to draw conclusions about trends in the frequency of breeding or the number of species participating. However, between 1971 and 1991 ten breeding events were recorded. Narran Lakes is regarded as one of the major sites for ibis breeding and colonial waterbirds such as ibis, egrets and herons only breed on a few large floodplain wetlands in Australia. The Narran lakes are one of nine major wetlands used by birds in the Murray-Darling Basin. It is not clear yet how waterbirds use the whole of the wetlands encompassed by Narran Lakes. Clearly more needs to be discovered about the relationship between water levels in the lakes and breeding, and the ecological study of the lakes now getting underway will assist in this understanding.

Bird breeding events are a function of wetted area, rate of fill, duration as well as season. Bird breeding events for many species seem to occur when the lakes are around 86% full.

4.3.2 Vegetation

Over 300 species of vascular plants have been recorded in the Narran Lakes Nature Reserve (the Ramsar site). The fauna is dominated by arid and semi-arid adapted species. Lignum occurs extensively around the lakes and riparian forest consists of River Red Gum, Coolibah, Black Box and River Cooba. Flooding is probably the main influence on species distribution, growth and reproduction.

4.3.3 Fish and Invertebrates

Information on the fish is scarce but indicates that juvenile Golden Perch have been found abundantly in Clear Lake which may be an important nursery area. The Lakes periodically support major fish breeding events. If this is so the period of connection between the lake and the Narran River at high flows may be important for enabling fish migration.

Little information on the macroinvertebrate communities is available.

The Panel is of the view that, on the evidence available to it, the Narran lakes are not yet showing signs of degradation.

It has been suggested by CRG that the ring tanks developed to hold irrigation water will provide alternative breeding and feeding areas for these waterbirds. This will of course depend on whether ring tanks provide both habitat and food sources that attract the birds. Undertaking bird monitoring in the area using standardised techniques can assess this suggestion.

4.4 Darling River

Several of the Rivers of the Lower Balonne contribute water to the Darling River, and hence are important in the context of the health of the Darling and MD systems, as well as the opportunities for downstream irrigators on the Darling River. While little data have been presented to us, one submission considered we should consider the impacts of the developments on the Lower Balonne downstream to at least Bourke. We have three sources of evidence about the current health of the Darling River.

The Scientific Panel that assessed Environmental Flows for the Barwon-Darling River reported in 1996 that the Darling system between Mungindi and Menindee was highly

impacted by flow diversions. Median monthly flow at Menindee is less than 50% of predevelopment; upstream at Mungindi it is les than 40%. (Scientific Panel Rpt P22. DLWC) That Panel made a number of recommendations to stop further abstraction of water and to manage flood pulses in a way that would protect the river as much as possible. The Culgoa system was reported as providing about 20% of the flow of this system.

The NSW Rivers Survey found the Darling River to be degraded in terms of its fish communities, attributable in part to changes in flow regime (Harris and Gehrke, 1997).

A more recent study is the Snapshot of the River Condition in the MDB (Norris, et al 2001). This assessment was done from the First National Assessment of River Health and used the macroinvertebrate data from Queensland which was used by the TAP, and has not been supported by subsequent studies. This means that the biological condition for the Culgoa in Table 2 is not correct in the light of more recent information; however, we believe the physical assessments still to be sound.

Table 2 River Health Assessments from MDBC Snapshot of River Health, (Norris et al 2001) Numbers refer to % of sites in each condition.

	Reference Condition	Significant Impact	Severe Impact	Moderately Modified	Substantial Modified
	Biological			*Physical*	
Condamine-Culgoa	49%	23%	28%	82%	18%
Darling	38%	50%	12%	81%	19%

The Panel accepts that the Darling River is significantly degraded and that changes to its flow regime is one of a number of contributing factors.

If 1999 levels of diversion were allowed, flows from Queensland into the Darling would reduce by about 10%, adding further stress onto the flows in the Darling.

The report from MDBC (Prasad and Close, 2000) gives details of the impact of various degrees of development on the Condamine-Balonne up to the potential extraction (the 'existing' case as we know it). The impacts are evaluated for the Lower Darling and Murray, and are surprisingly small; it appears that system losses between Qld and these points reduce the impact of reduced flows. Therefore any impacts on the Darling River are likely to be experienced in the upper reaches, probably between Bourke and the junction with the Culgoa.

It has also been recognized that reductions in small-medium flows of the Lower Balonne may reduce connectivity of fish populations between the Upper Balonne and the rest of the MDB.

5. Likely Future Ecological Conditions of the Lower Balonne System (ToR 4)

> ***ToR4 To review the range of likely future ecological conditions and trends in the health of the Lower Balonne River system, including its floodplains and wetlands.***
> **"**The review must examine and report on the likely trend in ecological conditions and health of the Lower Balonne River system and associated habitats in five, ten, twenty and forty years time given the current capacity to extract water from the system, whilst taking into account other natural resources management and resource use practices in the region. The review must provide a comprehensive statement about the adequacy of the available data and information to support these predicted outcomes, estimate the error or sensitivity involved in the prediction and provide justification for the key indicators used".

Predicting future conditions is difficult, and few submissions attempted detailed predictions. The NRM submission best addressed this issue, and identified drivers of change and likely trends. The SmartRivers supplementary submission (7th November 2002 Page 7) criticize the NRM submission for being based on the IQQM model, and argues that mean annual flow is less important ecologically than the larger floods which wet the floodplain. (Note that both NRM and the Panel support this latter contention).

From the submissions made to us, and our own understandings of this system, it is likely that the following bio-physical drivers of change need to be considered in attempting to predict the future conditions of the Lower Balonne system

- Changes in the flow regime (due to extractions, and the compensation flows from Beardmore Dam)
- Changes in land use in the Lower Balonne and upstream
- Sedimentation
- Agricultural chemicals
- Weirs and structures on channels and the floodplain
- Climate change
- Salinity due to land clearing, excess irrigation or seepage from storage's
- Infestation of plant or animal pests

The Panel was asked to comment on the adequacy of data available for predicting future conditions. In our view, the flow data and the modelling capacity give a good basis for predicting wetting patterns. The main difficulties with prediction relate to the unpredictability of the flood events, and especially whether or not their variability will increase in coming years due to climate change. We also have limited quantitative relationships between flow and the various biological outcomes of concern. Indeed, such relationships are the basis for a major NRM research project presently underway. Our present knowledge gives a strong basis for the qualitative relationships we have used in our predictive statements. The lack of quantitative relationships, and the variability of the flood patterns that drive the system make it impossible to give precise predictions of conditions in 5, 10 and 20 years.

5.1 Likely Changes In Flow Regime

As mentioned previously, extensive irrigation infrastructure has been developed in the last couple of years, and the river and floodplain has yet to experience the impacts of the potential level of extraction.

The NRM predicts (using IQQM modelling) that under present levels of development there is likely to be a substantial decrease (around 50%) of the frequency and extent of flood events across the lower floodplain. The Panel is of the view the modelling used is adequate for this purpose, and so believes the results to be indicative of what will happen. Flows during drier years would be virtually eliminated while average years would be down to 20% of pre-development flows. This means there would be a significant increase in the time between flooding for the lower floodplain.

Small floods (20,000 ML/day), that would have occurred on average once a year on the Queensland part of the floodplain and spill onto the floodplain, are effectively eliminated by the present licences. Medium floods (60,000 ML/day), which originally occurred about once every two years with substantial wetting of the floodplain, will now become small floods (NRM Submission P 21)

Modelling indicates that the end of system MAF will be around 47% of pre-development flows. SmartRivers Supplementary P 10 disputes this on the grounds of errors in flow measurement and in modelling, and assert it to be nearer 60%. Both figures have inherent uncertainty for the reasons outlined in Section 3.1 above, and support the recommendation to move to event management linked to ecological outcomes.

Given the recent nature of this development, we are yet to see the full consequences in terms of changes to populations of aquatic organisms and, more longer lived biota such as riparian and floodplain trees. The CRC strongly suggest that ecological condition of the system will get worse. In other words, ecological outcomes will not be fully realised (perhaps for several decades) as for example, flow-dependent reproduction and growth of long-lived plants and animals fails. Research in the Lower River Murray suggests time-lag effects of over 70 years (Thoms and Walker, 1993).

The projected median annual flows in the Culgoa River and Narran River at the Border are 24% and 32% of simulated natural respectively (NRM Submission, P24). These, and other flow statistics, indicate that the flow attributes are highly modified from simulated natural. Other Australian rivers that have similar levels of abstraction but for historically longer periods are now assessed as being in poor condition. For example, for the River Murray the 1994 median annual end of system flow is 27% of natural. The Snapshot of the Murray-Darling Basin Condition (MDBC 2002) assessed fish populations to be in very poor to extremely poor condition throughout the River Murray and macroinvertebrate communities in generally poor condition declining towards the river mouth.

5.1.1 Future Conditions of the Lower Balonne Floodplain

The Culgoa River at Brenda will see its event-median flood reduced from a volume of around 26,000 ML to 759 Ml (NRM Submission P 33). In only 12 years of the last 73 will there be flows equivalent to 40% of pre-development flows. It is difficult to quantify the biological impacts of these reductions. Downstream graziers claim their productivity is

already reduced by some 30% of what it was, and the full impact of existing infrastructure has not yet been experienced. We are advised by the CRG that there have been three periods (1984-7, 91-94 and 2000-), where dry periods of around three years have been experienced which could account for this observation. We anticipate changes to the wetlands and floodplain vegetation with what will be a significantly drier regime when the impacts of present infrastructure are experienced. In particular is likely there will be a loss of Coolibah vegetation which seems dependent of flood events for regeneration, although further work on the ecology of these communities would inform management of appropriate wetting regimes..

In its submission, the CRC for Freshwater Ecology suggested the following impacts of present water development:

- Reduced connections between the wetlands and floodplains of the Lower Balonne and the rivers which threatens biodiversity,
- Restriction of flows by levee banks has increased the depth and duration of flooding in areas that have historically experienced flooding about once every 1.5 years and this will be detrimental to plant vigour,
- Reduction in the frequency and duration of inundation of areas that historically have received flooding once every three years mainly located adjacent to the Culgoa river channel. These areas will be drier than under natural flow regimes, which is expected to be detrimental to the tree communities,
- Plant species will adapt to the drier regime with a reduction in the tree communities and an increase in grasslands.

The Panel believes that the important floodplain vegetation that has been protected in National Parks in Queensland and in NSW is at risk due to decreased frequency and duration of wetting due to the loss of medium sized floods. We believe these hydrological changes will lead to a loss of vigour and eventual replacement of these plant communities with grassland species.

5.1.2 Future Conditions of the Channels of the Floodplain

The CRC for Freshwater Ecology undertook an "Expert Panel" assessment of the impacts of the expected level of extraction on channels of the floodplain. They expect changes in channel form due to the changed flooding regime. They also predict that floodplain vegetation will contract to a narrower riparian fringe with the reduced flooding frequency.

With the possible exception of the Bokhara River, the low end of the flow regime also is markedly reduced. This may translate into:

- Reduction in permanent pool habitat (refugia)
- Reduced water quality in remaining pools – bigger temperature fluctuations (and DO), concentration of biota (aquatic and terrestrial), less frequent small 'flushes' to keep pools topped up.

These effects might be somewhat mitigated if "compensation flows" were targeted for ecological purposes as well as meeting stock and domestic demands, or by increasing the compensation flows to provide for environmental benefits.

Degradation of this system is not likely to be on a smooth trend, but will be episodic as particular dry periods, which may now be longer in duration of much of the system, impact on stream refugia and wetlands.

The Panel finds that the health of the river and distributary channels is likely to decrease with the flow changes that are expected. In particular the downstream pools that provide refuges for fish and other biota may become more restricted and water quality may deteriorate.

5.1.3 Future Conditions of the Narran Lakes

The NRM modelling indicates that Narran lakes will experience wetting patterns sufficient to trigger bird breeding less frequently now than in the pre-development condition. In the pre-development phase, the wetting was sufficient to trigger bird breeding about once every two years on average; under current levels of development it is more like every seven. Given the considerable variations around these mean figures we anticipate much longer periods of dry conditions for Narran lakes with consequential replacement of aquatic vegetation with terrestrial vegetation, and consequent loss of habitat when the lakes do subsequently wet.

In 1996 there were two significant events. With no extraction, the first one (Jan-Feb) would have filled the lakes (ie > 180GL) from near empty at the end of 1995; they would have got to two-thirds full in this event with full potential extraction. As it was, there was a second flood in June 1995, which filled (ie topped up) the lakes under both scenarios.

The event in 1997 (mid-Feb to mid-Apr) would have filled the lake yet again with no extractions. The potential extraction scenario would have the lake storage reaching about 145GL. A similar comment applies for 1998 and 1999. The 'no-extraction case has Narran Lake filling in those years (> 180GL), but reaching a peak of 155GL in each year under the potential extraction scenario.

The Panel anticipates changes in the Narran lakes will begin when the flows are altered to the extent now possible, and will continue to have increasingly obvious ecological impacts over the next forty years as has been the case in other terminal wetland systems such as the Macquarie marshes. We anticipate the Lakes will fill less frequently, causing longer dry periods leading to an encroachment of terrestrial vegetation to replace the aquatic vegetation and a reduction in the frequency of successful bird breeding events.

The Panel notes that the Lower Narran Lake has already been altered due to floodplain cropping. Many other regional wetlands have also now been changed in this way, including some of those listed in the 1995 Directory of Nationally Important Wetlands. This reduction in regional habitat makes it especially important to protect the remaining wetland habitat.

5.1.4 Future Impacts on the Darling River

It is possible that the level of extraction and associated water resource development will affect longitudinal connectivity between the Condamine/Balonne and other systems in the Darling. For example, species of fish and crustaceans show widespread movement among the tributaries of the Darling (e.g. *Macrobrachium,* a freshwater prawn). The current activity in the study region could impede this movement and isolate populations in the upper Condamine and Maranoa Rivers.

The Panel notes that the possible level of water extraction in the Lower Balonne puts further flow related stress onto the already degraded upper Darling, but that these flow changes are mitigated downstream and they will be minor in the Lower Darling and the Murray. The ecological impacts of such flow changes are not known.

5.1.5 Summary Statement

The Panel supports the contention of the CRC for Freshwater Ecology that there will be significant long term degradation of the Lower Balonne floodplain and of the Narran lakes in particular once the system experiences the water extraction that is possible with the present infrastructure. We see a long period of decline, with the full impacts not necessarily being fully obvious within the 40 year time scale of this assessment, due to the background high flow variability.

5.2 Other Factors Affecting Health of the Lower Balonne System

It is well understood that changes to flow regime is an important cause of the degradation seen in many over developed river systems, but it is important to appreciate there are a number of other factors which can lead to degradation and need to be manage

5.2.1 Land Use Practices

As was stated earlier (Section 3.2) we do not believe that changes in land use from wooded to grassed area will have much impact on runoff at the basin scale at the rainfalls experienced in the upper catchment.

The replacement of extensive grazing with cropping introduces cultivation and the use of agricultural chemicals into the system that may have specific impacts. The reduction of grazing pressure probably has a beneficial impact on the condition of riparian vegetation.

5.2.2 Sedimentation

There is some evidence from Thoms that sedimentation rates in the channels of the Lower Balonne have increased over the period of white settlement, presumably due to increased erosion during periods of over grazing and due to runoff from cultivated lands. The Beardmore Dam and Jack Taylor Weir probably act as silt traps to protect the Lower Balonne from sediment loads generated upstream, but there would be significant sediment generated within the Lower Balonne itself during certain periods.

5.2.3 Agricultural Chemicals

The biological data relating to distribution of both fish and invertebrates does not appear to indicate they have been impacted significantly by toxic agricultural chemicals at present, since the populations appear comparable with that of adjacent rivers and no obvious downstream trends occur.. The management of chemicals in the cotton industry has improved significantly in recent years and if any problems are evident we believe they would be localized.

5.2.4 Weirs and Structures

The bifurcation weirs installed to divert flow are likely to drown out during floods and are not likely to block fish migration, although their impacts during spawning periods in late spring-early summer may be more serious, and it may be necessary to consider installing fish ladders to mitigate these impacts. Clearly the larger structures of Beardmore Dam and Jack Taylor Weir do provide significant blockages to fish movement that may cause longer term declines, or at least reduce the ecological resilience of the Lower Balonne system.

There has already been extensive loss of floodplain for agricultural development. Each levee structure will further isolate the river from its floodplain, and will lead to further deterioration in the health of the river and the floodplain.

The Panel is of the view that no further losses of floodplain should be allowed pending scientific studies demonstrating they will have no impacts on the health of the Lower Balonne system.

5.3 Climate Change

Work undertaken by the Cotton RDC suggests there is a 50% probability of the average flows for the Balonne River at St George being 4% less than those under the existing rainfall patterns, and a 5% probability of the average flows being 12% less.

This represents an additional risk for the long-term health of the Lower Balonne system considering the already significant changes to the flow regime that it will experience under the existing situation. However, given the natural variability in the system, the changes due to climate change will be hard to detect from the background 'noise'.

5.4 The Salinity Risks

The salinity hazard map for the area released by NRM received considerable publicity, and has been misunderstood by some. The map was developed to identify priority areas for more detailed investigation of salinity. The way the map was constructed meant that 20% of the landscape mapping units was to be shown red as the priority area for investigation. The more detailed studies, using air-borne radiometric sensing and bores to ground truth the data are now underway, and indicate that while there are patches of high conductivity (salt in the soil profile), they appear to be somewhat isolated from the main aquifer that underlies the Lower Balonne irrigation area.

It is noted that several of the irrigators have employed consultants to develop salinity management plans at the farm level. It is apparent there will be much more information to base management actions over the next 12 months. It is likely that the particular risks of salinity can be managed in the Lower Balonne with appropriate land management, although considerable care must be taken to avoid any discharge of saline waters to watercourses or wetlands in the area.

The Panel is of the view that salinity is a potential problem for parts of the Lower Balonne, and that NRM and agencies need to act to investigate and manage it. There is significant salt in the landscape, but it appears to not be uniformly distributed. It may be mobilized by rising groundwater that could arise from clearing of native vegetation, seepage from farm water

storages or from excessive irrigation. We support ongoing assessment and management of this problem which we understand is occurring under the NAPSWQ.

6. Setting Flow Targets for the Lower Balonne System – Healthy Working Rivers (ToR3)

> ***ToR 3 To review the current relevant scientific information in order to propose an ecological definition of the healthy working river applicable to the Lower Balonne context.***
> "The review should examine available scientific information and provide comment from an hydrological and ecological perspective about what would be the key attributes of and characteristics exhibited by a healthy working river in the Lower Balonne area".

6.1 Submissions to the Review

Few submissions related to this Term of Reference. The Departmental submission pointed to some of the ecological assets of importance, but did not propose flow targets for any of them.

The SmartRivers submissions argued that the concept of "healthy working rivers" required a judgement by the community of the sort of river that they wanted after balancing socio-economic interests. They also argue that maintenance of fish populations is an important indicator to them. The Balonne Community Advancement Committee supported this view. SmartRivers assert in a supplementary submission (7th November, page 6) that ecological targets should not be set by academic scientists alone but require a range of community opinions. However SmartRivers did not propose any specific ecological targets.

NSW National Parks and Wildlife argued that the present level of water extraction is excessive and that considerable rehabilitation of flows is required to ensure inundation of the Lower Balonne floodplain. Various downstream landholders also stressed that the reduction in floodplain flooding on their properties due to water harvesting and release strategies from Beardmore Dam.

The Environment Australia submission argued that a healthy river is one where the ecological integrity is maintained over time. Ecological integrity refers to the capacity of the system to support and maintain a balanced, integrated, resilient and adaptive biological communities.

6.2 The Time for Impacts to be Experienced

Given that the evidence before us suggests that the rivers and the Narran lakes themselves are presently in a reasonably healthy state, it is tempting to assume that the current levels of water extraction are not having any particular impacts on the health of these two elements.

There are two reasons why this would be an inappropriate conclusion.

- Firstly, the system has not yet experienced the full potential impact of present water extraction infrastructure (due to recent increases in diversion capability and recent low flows), and

- Secondly, there appears to be a significant lag between when a flow regime is altered and when the biological impacts become apparent.

Most of the increase in storage has been recent (storage capacity on the floodplain has increased from about 90 GL in 1995 to 740 GL in 2001, with more than half of this in the 2001 year (Calibration Report, Fig 8.2).

The Panel notes that the river has not experienced a flow regime that will result from the extraction with the current levels of infrastructure development. It is therefore likely the present health of the Lower Balonne river system reflects extraction patterns from some period in the past.

Various submissions, especially those from NSW National Parks and Wildlife Service and the CRC for Freshwater Ecology indicate that a significant lag time can be expected between when a flow regime is altered and when the biological consequences will become apparent. This has been the experience in rivers in the southern part of the MDB, and may be applicable to the flood pulse rivers of the Lower Balonne.

The Submission from NSW NP&WS indicates negative impacts of flow regulation on the biodiversity of important wetlands are still becoming expressed after nearly 40 years. The most visible impacts are on terminal wetlands. Their submission argues that most of the important values of Narran lakes will be lost when reduction in volumes and frequencies of flooding approach 60% of natural, although the impacts are triggered much earlier. They point out that stands of river red gum in the Nature reserve are already close to ecological tolerance under natural flow regimes. If this component of the wetland should disappear, it will remove nesting habitat for several species. The lignum communities are seen to have greater ecological tolerance.

The Panel accepts that it takes some time for a river and wetland system to exhibit the signs of stress from alterations to flow patterns, and so the present condition of the rivers and wetland may not reflect the present level of actual extractions experienced by the river to date.

6.3 The Concept of River Health

A river in good ecological health refers to a fully functional unstressed river. The river may also be providing important goods (eg biota) and ecosystem services for humans but it does not show significant signs of stress. A healthy river has the capacity to recover from stress induced by disturbance, whereas an unhealthy river does not have this resilience and capacity to recover (from Downes et al, 2001). In the context of the Lower Balonne it is important to appreciate that a river refers to both the channels that carry dry weather flows and revert to chains of ponds in dry periods as well as the floodplains and wetlands of the system. This includes terminal wetlands such as the Narran lakes.

Cullen (2002) has proposed a simple flow classification as it relates to river health that is one approaches being developed to protect ecological assets in both the MDB and in Southern Africa. This is based around the measure of mean annual flows, the appropriateness of which is questionable for the flood pulse rivers of the summer rainfall zones. This is consistent with other definitions being developed in the MDB which suggest that if less than a third of the water is being extracted the river has a high probability of being a healthy working river;

if the river is getting less than half its original flow, it has a low probability of achieving this condition.

Table 3 Australian River Flow Classification (Cullen, 2002)

River Class	Maximum Mean Annual Flow Extraction %
Heritage River	< 5%
Conservation River	< 15%
Sustainable Working River	< 33%
Managed Working River	< 67%

The Panel has questioned the use of MAF as a management tool in the flood systems such as the Lower Balonne. If we use such a measure merely as a broad indicator, the Lower Balonne system would unlikely to be regarded as a sustainable working river with the present level of possible extraction.

6.4 Defining a Healthy Working River in the Lower Balonne

Experience elsewhere in the MDB has indicated that the floodplain, floodplain wetlands and in particular the terminal wetlands are the first elements of the river system to be damaged by changes to flow regimes.

Consequently, we make the assumption that ensuring an appropriate flow regime is provided to maintain the floodplain and its wetlands, the flow regime will most probably maintain a healthy working river. A healthy working river in this environment will be able to maintain populations of native fish, which requires maintaining waterholes as refuges for such fish in dry periods. It also requires reasonable invertebrate populations to provide a food source for fish and waterbirds. These various biological communities will not be in a "pristine" state, but will have the resilience to recover from changes due to climate, pollution, sedimentation and flow changes.

The Panel is of the view that the dominant consideration in the Lower Balonne system is to ensure the Narran lakes receives an appropriate flow regime to maintain the vegetation and bird communities. If this is achieved, the flow regime in the Narran River will be adequate to maintain the river and distributary channels in good condition.

The Panel is concerned that the possible level of extraction will exacerbate damage to the Lower Balonne floodplain. We believe a loss of productivity in the grasslands is evident from landholder observation, and we anticipate a loss of the area supporting tree vegetation and its replacement with grassland over the longer time frame. Further studies are needed to identify wetting regimes that might avoid this possible decline.

6.5 Defining Appropriate Flow Regimes to Maintain the Narran Lakes

These lakes flood periodically and do experience dry periods. Prior to irrigation development they filled on average every two years; with the present level of development they are

expected to fill on average once every six years. The wetting has always been very variable, but with current developments the lakes will experience longer dry periods which may alter the vegetation communities and allow the incursion of more terrestrial species as has been observed in other wetlands with reduced wetting frequency.

The critical question for managers is what frequency of flooding is necessary to maintain the ecological values of the Narran lakes, and if damage does occur is it likely to be readily reversible.

The relevant aspects of a flow regime appropriate to maintain a wetland include:

- Volume of water
- Frequency of inundation
- Duration of inundation
- Seasonality of inundation
- Variability of wetting

From this is it obvious that using a hydrologic measure such as some proportion of Mean Annual Flow is a crude measure for defining an appropriate wetting regime in a distributary system like the Lower Balonne which experiences flood pulses rather than a more constant flow regime. Beside the errors in measurement of MAF discussed earlier, the ecological significance of such a measure is questionable.

The Panel is of the view that the health of the Lower Balonne system and the interests of irrigators would be better served if a more appropriate measure of the required wetting regime than MAF was developed and used to guide management of water in the Lower Balonne.

The MDBC are about to commence a major ecological study of the Narran lakes to be carried out by the CRC for Freshwater Ecology. This will be an important study, and will provide a firmer basis for defining an appropriate flow regime than we have before us. Therefore, our recommendations must be regarded as tentative and should be revisited once this study is complete. However, to protect the Narran lakes immediate action is required to provide the recommended wetting regime even if further knowledge allows a refinement of this regime.

In its submission the NSW NP&WS expresses its concerns that the duration of flow events may be near the minimum required for bird breeding. Both major breeding events (1996 and 1997) were completed with only one week to ten days to spare, compared to earlier events when there was several weeks tolerance. The Service is concerned that we will now see breeding events abandoned because of premature shortening of flow events.

The NRM Modelling indicates that Narran lakes would have seen flooding sufficient to trigger bird breeding 37 times over the 75 year period from 1922-95 with no development, and with the present level of development these will occur only 11 times, 30% of pre-development (DNR Submission P32). NSW NP&WS have stated that serious degradation is expected should flows be reduced to 60% of pre-development (NSW NPWS Submission P6).

In January 1996 the Narran Lake Nature Reserve was flooded and water reached 100cm on the gauge on the north shore of Back Lake. By the end of April the level had fallen to 11cm but a subsequent flood raised it to 100cm by June. The level then fell steadily to 0cm by the end of October. Waterbird breeding occurred only during the first flood with peak breeding from February to April. Water levels during these three months varied from 50 to 11cm. In 1997 flooding began in February and the water level reached 100cm by late March. It declined to 10cm by early July and to 0cm by August. Breeding occurred throughout the inundation period but only 9 species of waterbird bred compared with 18 species in 1996. The scale of breeding for the colonial species e.g. Straw-necked Ibis, was also much reduced in 1997. There was no obvious explanation for these differences.

An interim finding by the Review Panel, to be reviewed once the ecological study of the Narran lakes is completed, is that the Narran lakes need to be flooded on average once every 3.5 years if its ecological values are to be maintained. This estimate is based on the NSW NP&WS submission that degradation will occur if volume and frequency of flooding is reduced below 60% of pre-development.

7. Reversibility or Mitigation of Expected Impacts (ToR 5)

ToR5 To review the reversibility or the lessening of the predicted trend in ecological condition outlined in 4.
"The review must canvass and report on strategies, including those not solely related to water resource development, that may be likely to reverse or lessen any identified future negative trends in ecological condition and health of the Lower Balonne River system and associated habitats in five, ten, twenty and forty years time. The review should also comment on any trends that may be irreversible and provide reasons therefore."

7.1 Mitigating the Impacts of Flow Changes

The Panel believes that the change of flow regime that can result from extractions under the present level of infrastructure will be the most significant factor affecting the health of the Lower Balonne system.

In a pulsed distributary system such as the Lower Balonne we believe it is necessary to develop more sophisticated approaches to managing flow than on the basis of MAF statistics. The MAF is inherently imprecise in river systems with such large year-to-year fluctuations. It is not surprising that so many of the studies of the Lower Balonne have recommended adoption of an event-based management approach.

The Panel believes that event-based targets should be adopted for water and environmental management in the Lower Balonne. A consideration of sampling errors alone indicates that targets linked to MAF should be avoided

We indicated in section 5 that an interim target for the maintenance of the Narran lakes is to provide flooding on average every 3.5 years to the 86% level identified as a trigger to bird breeding This wetting target is some 30% less frequent than the pre-development situation, but is 30% better than the wetting regime that will be experienced with the present infrastructure.

The extraction levels to meet this target would be estimated by simulation with the IQQM model, with extraction scenarios altered until the target is reached.

The Panel recommends that the target of wetting on average every 3.5 years for the Narran lakes, and appropriate frequency for the two Culgoa National Parks, be achieved through close consultation with the community, given the need for a cooperative approach to manage the large number of extraction points and individuals involved. With the calibrated model now available this can be readily achieved and such consultations should be completed within a period of three months.

We are not in a position to provide information on the appropriate wetting regimes for the Culgoa National Parks due to the absence of scientific work brought before us. This is identified as a research need. This work should start immediately since it may take a period of five years to obtain useful results.

The SmartRivers submission (page 9) asserts that nothing is irreversible given time and commitment. While the Panel does not necessarily accept this position, the level of commitment required may be very high, and there has been in other situations an expectation that the taxpayer will fund restoration. It is likely that protecting an ecological system in the first place is likely to be 10-100 times cheaper than trying to restore it (Prime Ministers Science, Engineering and Innovation Council, 2002)

The Panel notes that experiences elsewhere have shown that it is technically and politically much more difficult to restore degraded systems than to prevent degradation in the first place. We therefore urge a conservative approach with immediate action to provide the required wetting regime with ongoing monitoring and assessment.

Increasing flows to the Narran lakes will have no benefit to the Culgoa floodplain or the Darling River, and may divert water away from these assets. Augmenting flows to the Culgoa floodplain could result in increased flows reaching the Darling that might have some beneficial impacts on the Upper Darling but would have little impact on the Lower Darling or Murray systems.

7.2 Other Catchment Management Strategies to Protect the Lower Balonne.

As was stated earlier, there are a variety of other factors beside flow regime that can cause impacts on the health of the Lower Balonne. Several of these have the capacity to have devastating impacts on the Lower Balonne system if they are not managed appropriately.

Mis-applications of agricultural chemicals and chemical spills have the potential to have significant biological impacts on fish and other organisms. We see no evidence of impacts to date, and note that most cotton growers aim for a zero-discharge outcome, but point out the need for all landholders to be using state of the art approaches to chemical management to ensure no mishaps. It may only take one accident on one farm to decimate fish and bird populations!

Salinity is a risk factor presently under intense investigation in the region. The groundwater salt reserves are complex, and excessive application of irrigation water has the potential to bring salt to the surface and cause the devastating impacts seen in some other Australian irrigation areas. Similarly, the clearing of native vegetation in the catchment needs to be

carefully assessed for its hydrological impacts to ensure it will not contribute to dryland salinity.

Another potentially serious factor is the introduction of pest plant or animal species. The introduction of plants like salvinia, water lettuce or water hyacinth to the storage's and waterholes of the Lower Balonne could have a serious impact. The introduction of pest fish species could damage native fish populations. The community and relevant agencies need to be on the lookout for such introductions, and have in place agreed management responses so that action can be taken while there is still a chance of controlling the introduction.

It is obviously important to protect the riparian areas and the instream habitat of the channels. We don't see these as under particular risk, although unrestricted grazing access is a degrading factor in such systems.

8. Ongoing Monitoring of Health of the Lower Balonne System

> ***ToR6 To advise on river health monitoring and risk assessment frameworks for determining the future ecological condition of the Lower Balonne River system.***
> *"*Based on the findings from the issues outlined above, the review should examine and report on the scientific appropriateness of river health monitoring, assessment and reporting methodologies being proposed for the Lower Balonne River system by government agencies and other scientific entities working in the region, and report on the key elements of an appropriate ecosystem health monitoring and risk assessment framework for the Lower Balonne".

8.1 Why Invest in Monitoring?

There are clearly many knowledge needs one would like to have to assist in managing the water resources of the Lower Balonne. In situations where there are long lag times between an action and its consequences becoming evident, one seeks early information to allow for adjustments to management regimes. Such an adaptive management approach relies on effective monitoring of the resource, and regular interpretation of what is coming out of a monitoring program so that actions are taken. It also requires an effective research program to allow the linkages between actions and effects to be further understood.

The monitoring program of the Lower Balonne needs to be designed around getting early information on the ecological assets of concern. The information being collected needs to address the current condition (or state) of the resource, and should also include information on the pressures on that resource.

Monitoring is undertaken to inform management. It is designed to give early warning of changes that may be significant to enable management interventions to be made in a timely manner. The management interventions may be made by landholders, by NRM staff or other agencies.

8.2 Risks to the Health of the Lower Balonne

Ecological risk assessment (ERA) is now being used to assess the level of risk to the health of river ecosystems posed by multiple stressors (e.g. flow, salinity, toxicants, nutrients, exotic

fish species). Risk is considered as the product of the *probability or likelihood* of a hazard and the *consequence* if that hazard occurs. Ecological risk is defined as:

Ecological risk =*likelihood* of ecological effect x *consequence* of that effect.

ERA provides a basis for comparing and ranking risks. This enables monitoring effort to be focussed on the most important elements, and helps focus management activity on the most important risks.

Our task has been to review the existing scientific work, not to undertake new studies. No substantial ERA has been placed before us, and indeed the quantitative linkages between actions and outcomes are not well enough known at this stage to do other than a simple qualitative study. Thus we have attempted to provide some guidance as to how a substantial ERA might be undertaken.

The risks to the health of the Lower Balonne have been identified in numerous submissions to this review, and the key ones are identified below. Unfortunately there is insufficient information available to us to quantify the likelihood of occurrence or the potential impacts that would enable a quantitative ranking of the risks

Table 4. Preliminary Risk Assessment for Lower Balonne Floodplain

Risk	Likelihood of Occurrence	Potential Impact on Lower Balonne Floodplain
Reduced wetting of floodplain vegetation and wetlands due to water extraction	High	Significant loss of wetland bird breeding and vegetation expected
Reduced wetting due to climate change	Medium	Minor
Further isolation of floodplains by banks	Medium	Incremental loss
Impacts of in-stream weirs and dams	Medium	Probably minor due to flooding out
Impacts of upstream land-use changes on water volumes	High	Minor
Damage to riparian and in-stream habitat	Low with present landuse	Incremental damage
Pollution with agricultural chemicals	Medium	Could be devastating to floodplain biota
Eutrophication	Medium	Periodic toxic blooms could impair stock & domestic use
Rising water tables and Salinity	Medium	Potential Loss of farmland Salinisation of channels and wetlands
Introduced plant pests	Medium	Potentially serious in storages
Introduced fish	Medium	Potentially serious to native fish
Increased turbidity and TSS	Naturally high	Reduced aquatic production
Deoxygenation	Occasional	Localised fish kills

8.3 Selecting Indicators for Monitoring

The outcomes being sought by management and the community are largely biological outcomes, so the key outcome measures should be biological. River health assessment in Australia so far is largely built around invertebrates, and to a lesser extent fish communities. These are important aspects in the Lower Balonne, but additional biological outcomes that are important include significant bird breeding events, wetland vegetation, floodplain vegetation and algal bloom events.

King and Day (2002) recently reviewed the approaches to the assessment of river health being used by NRM and found that the approaches being used are recognized and appear to be properly undertaken, although they expressed some concerns with the level of reporting. Unfortunately this review only considered some of the earlier work on river assessment in the Lower Balonne and did not consider more recent work so we have discounted their findings with regard to river health in the Lower Balonne.

Marshall et al, in NRM Supplementary Submission (Chapter 4) report on an important research project being undertaken to identify relationships between the ecological condition of rivers and the various drivers of change including flow and land use. Preliminary findings are showing a strong association between flow and land use and ecological condition and suggest complex multi-driver relationships that will require ongoing work to elucidate. The Panel is strongly supportive of this research activity which is evaluating a number of biological measures.

Physical and chemical measurements are useful in helping understand why changes may be occurring, but are themselves only poor surrogates for direct biological measurement. Appropriate measures will come from the risk assessment that identifies areas of risk that warrant ongoing monitoring.

Table 5. Key Indicators for Monitoring Health of the Lower Balonne Floodplain

Ecological Assets	Core Biological Measures	Core Phys/Chem Measures
River Channels of Lower Balonne	Invertebrate communities, Ausrivas	In-Stream habitat
	Fish communities	Flow regime
	Riparian habitat	Nutrients, agric chemicals
Culgoa Floodplain Nat Park	Extent of Coolibah communities	Wetting frequency and duration
	Condition of wetlands	
Narran Lakes	Bird breeding events/decade	Wetting frequency and duration
	Extent/condition of wetland vegetation	
Darling River	Invertebrate communities, Ausrivas	In-Stream habitat
	Fish communities	Flow regime
	Riparian habitat	Nutrients, agric chemicals

The Sustainable Rivers Audit has been designed for the MDBC to give a Basin wide audit of river health, and is an appropriate framework on which to build additional monitoring as required to meet the specific needs of NRM and other stakeholders in the Lower Balonne.

It does need to be augmented in the context of the Lower Balonne. In particular we believe it is important to document significant bird breeding events in the Narran lakes, and to record changes in vegetation both in the Narran lakes and in the Culgoa floodplain. We believe there are remote sensing technologies available to undertake this task.

The Sustainable Rivers Audit of the MDBC is an appropriate base framework for monitoring, and is presently being tested and developed in the Condamine-Balonne. Additional indicators such as bird breeding events, fish breeding events algal bloom incidence and vegetation communities need to be incorporated

8.4 Development of the Biological Sampling Program

The findings from the Marshall study should be used to further refine the biological-sampling program.

The invertebrate sampling techniques are appropriate for the broad scale spatial assessment that needs to be made in this region. The invertebrate data should continue to be collected with protocols that are compatible with the AUSRIVAS models that have been developed for the region. The reliability of the regional models themselves, particularly the model for the bed habitat, needs to be assessed using a greater range of sites than provided by the Lower Balonne alone. Such an assessment should include sites that are known to be subject to specific disturbances so that the full range of O/E scores likely to be encountered can be assessed. It would also be worthwhile to list taxa that are expected by the models but not caught, especially at those sites where the O/E ratio is significantly less than unity. Such lists of taxa may give insight into the causes of any degradation and may indicate whether spatial or temporal trends in particular taxa are present.

The fish monitoring work is also particularly important in helping understand the health of the Lower Balonne system and should be continued. The sampling techniques being used are appropriate. Attempts should be made to sample fish in all seasons for each important monitoring site. It is evident that seasonal variations occur in the fish catches. In order to take seasonality into account in any statistical analysis such as analysis of variance, it helps greatly to have equal numbers of samples at each site through time. The types of statistical analysis that should be applied to these data are complicated and their interpretation is often only possible if equal numbers of samples have been taken. There are particular challenges in interpreting fish data in these highly variable systems, and the work already undertaken needs to be extended in an attempt to identify significant trends and relationships. This work needs some high level statistical guidance.

8.5 Research Needs

Terminal wetlands

Research programs are vital for the proper conservation and management of the terminal wetlands such as the Narran lakes, in particular for elucidating the relationship between filling of the wetlands and bird breeding. Suggested research has been described in detail by

the CRC for Freshwater Ecology scoping study on the Narran lakes (for the MDBC in September 2001). The priority suggestions are that work should be undertaken on the hydrology of the lakes and the Narran river, on monitoring water quality during baseflow and floods, on mapping habitats and on monitoring the main aquatic groups especially the waterbirds and the riparian vegetation.

The Panel is of the view that the proposed ecological study of the Narran lakes is important to the effective management of the Lower Balonne floodplain and should be undertaken without delay.

Wetting regime for vegetation

It is also important for Queensland and NSW agencies to develop a better understanding of the wetting regimes needed to maintain the Coolibah communities in their parts of the floodplain .

Evaporation

Evaporation is of key importance in an area like the Lower Balonne. In particular, evaporation from Lake Beardmore and from off-stream storage's is a significant water loss to more beneficial usage. It is an important factor in the calculation of Type A water using the DST model.

The Panel noted that the estimates of annual evaporation from the Beardmore Dam in various reports vary markedly, viz

- PSM Study 1926 mm
- SMEC 1663 mm
- QNRM 1590 mm

and believe that recent developments in the estimation methodology (using relevant climate data) would greatly reduce the uncertainty.

In view of the importance of evaporation in the Lower Balonne, the Panel recommends that a specialist study be undertaken of the most accurate way to estimate evaporation from typical water storage's, and the means by which evaporation loss might be minimized.

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Appendix A. List of Submissions

1. Department of Natural Resources and Mines, Qld, and supplementary
2. Smartrivers, and supplementaries
3. Cubbie Station
4. National Parks and Wildlife Service, NSW
5. NSW Fisheries
6. Balonne Community Advancement Committee
7. Environment Australia
8. Mr Reg Betts
9. Environment Protection Authority, NSW
10. Prof Brian Roberts
11. CRC Freshwater Ecology
12. B&W Hagarty
13. Department of Primary Industry, Queensland
14. Fox & Thomas
15. Agriculture, Fisheries and Forestry, Australia
16. Department of Land & Water Conservation, NSW

Appendix B The Ecological Assets of the Lower Balonne

THE FLOODPLAIN OF THE LOWER BALONNE

The floodplain of the Lower Balonne, below St George, is a complex mosaic of vegetation types that are dependent on periodic inundation by floods for their survival. Of the roughly 20,000 sq km of floodplain a relatively small area has been developed for irrigation, but the ecological asset of concern is the remainder of the floodplain and its wetlands.

Geomorphological studies of the main river channels in the Lower Balonne show the channels of Briarie Creek, Ballandool River and Bokhara River are inherently unstable (Thoms et al., 2001). Consequently, small changes to the flow of these systems are likely to lead to significant changes in channel morphology. Thoms also suggest that sedimentation rates on parts of the Balonne Floodplain have increased by an order of magnitude since European settlement. This is in large part due to increases in sediment supply from the upper catchment.

A study of the floodplain vegetation of the Culgoa, Birrie and Narran Rivers identified 175 species, of which only 8.5% were exotics which is one of the lowest records of introduced species in the MDB (Dick 1990). The Coolibah woodlands in the Lower Balonne are some of the most extensive and contiguous communities remaining, as are the grasslands of the Narran, Birrie and Culgoa floodplains.

Sims and Thoms (2002) report on the use of satellite imagery to map the vegetation communities and to map areas inundated by floods of various return intervals. They report the most vigorous vegetation growth occurred when flood frequency was between 1.25 and 1.75 years. In high flood frequency areas the vegetation is dominated by river red gum, coolibah and lignum and in less frequently flooded areas the vegetation is dominated by grasslands and Bassia sp. Other studies have supported the idea that these differences are due to wetting patterns from floods rather than from the effects of local rainfall or soil nutrients

There are some 1.3 million ha of wetland mapped in the Condamine-Balonne catchment (about 8% of the catchment). This is the highest percentage of wetland of any catchment within the MDB, with floodplain being the most extensive, with around 18,000 ha of freshwater and saline lakes.

The Lower Balonne floodplain contains two listings in the 3rd edition of the Directory of Important Wetlands in Australia. The Balonne River Floodplain wetlands (QLD) represent a significant aggregation of permanent and ephemeral billabongs and swamps on the floodplain, although many of those listed appear to now have been degraded through agricultural activity. These systems range from ephemeral wetlands to permanent billabongs. The actual area of the wetlands is in the order of several hundred hectares spread over approximately 24,000 ha of floodplain. Water resource development in the Balonne floodplain is recognised as a threat to the ecological integrity of these wetlands (www.ea.gov.au/cgi-bin/wetlands/reportwets.pl).

Culgoa Floodplain National Park (Qld)

Culgoa Floodplain National Park is 42 856 hectares comprising the Darling-Riverine Plain and the Mulga Lands. The vegetation is diverse consisting of Coolibah, Black Box, Brigalow, False sandalwood, Gidgee, Poplar Box, River Red Gum, Cypress Pine, Mulga, Western Bloodwood, Turpentine, Needlewood and Wilga The Balonne Shire covers 37 433 hectares of the park and the Paroo Shire 5 423 hectares.

Most of the floodwater over the past 100-year history of this area has come from the Culgoa River. Water from the Culgoa covers approximately 20 000 hectares of the park during a high flood. The water from the Culgoa enters the park from the northeastern boundaries and flows steadily across the park in a south south-westerly direction. The flooding of this type is very important to the sustainability of the ecosystems.

The rainfall and flood records of Brenda Station are an accurate indicator of the flooding pattern at Culgoa. Brenda station joins the National Park on the southern boundary and is situated on the Culgoa River to the south east of us. The flood records of Brenda Station, 7 kilometres away, were provided by the Peterson family, who have lived there for three generations. There have been 107 flood events recorded in the period 1890-1999.

There is flooding on the park that is not associated with the Culgoa River, from the Wallam and Mungalalla Creeks to the north west of the park, but local knowledge sources have mentioned that it takes a lot of local rain to flood these areas, and history tells us this happens on rare occasions. To the far north west of the park, in the Burrenbah section, flooding occurs from the Nebine Creek, this requires local rain but catchment rain to the north can provide enough water for extensive flooding to this area of the park. Approximately 5 000 hectares would go under water from flooding of the Nebine.

Culgoa National Park (NSW)

Culgoa National Park is located in north-western NSW, adjacent to the Culgoa Floodplain National Park in Qld, and protects a section of the Culgoa River and associated floodplains. The 22,430 ha park was gazetted in April 1996.

The natural values are high and it is important for the conservation of many of the native plants and animals of the region. The Park conserves several vegetation communities which have been extensively cleared or modified by agriculture in nearby areas and are otherwise poorly represented in NSW reserves. Low lying alluvial plains dominate the park and are characterised by dense Coolibah woodland, which grades into open grasslands east of the Culgoa River. The park protects a section of possibly the largest contiguous tract of Coolibah *(Eucalyptus Coolibah)* woodland remaining in NSW. West of the river the vegetation is a complex mosaic of Coolibah, gidgee, black box and brigalow.

The Culgoa River commences in Queensland and flows across the border to the Barwon River. Semi-arid river systems like the Culgoa are characterised by highly variable flow regimes. Flood events occur mainly in summer and autumn and are generally channel floods. Fluctuations in river height primarily result from changes in rainfall in Queensland but also rainfall in the local area and diversion of water for domestic and agricultural purposes. Heavy rainfall in Queensland causes large quantities of water to move through the river

system and inundate the channel country. The frequency and size of the flooding is highly variable and difficult to predict.

The catchments of the Culgoa River have been modified for irrigated agriculture. This regulation has the effect of reducing both overall flow and flow variability. There are some 13 weirs in Queensland along the Condamine/Culgoa system and four bifurcation weirs. As a result natural flows have been significantly modified.

These flow changes have occurred in the past decade and there have not yet been any obvious signs of system collapse but the long term effect on the floodplain vegetation due to changes in flooding regime is unknown. It appears that species such as Coolibah and river red gum that rely on periodic inundation to maintain vigour and to regenerate may decline.

NARRAN LAKES

The Narran Lakes system comprises a series of interconnecting terminal drainage lakes of the Narran River – Back, Clear and Narran. The Narran River is the eastern most anabranch of the Balonne River and historically carried about 25% of the discharge. Under potential levels of water abstraction, IQQM modelling indicates that median and mean flows reaching Narran Lakes will be reduced to approximately 24% and 43% respectively.

The Narran Lakes system receives water at lower flow levels than the lake beds further north along the Narran River and hence fills more often and holds water for longer periods than many of the regional wetlands. At moderate flows, water fills Clear Lake and then back-floods into Narran Lake. The water level in Clear Lake can drop very quickly if flows are not sufficient to keep water levels up in both Narran and Clear Lakes (http://environment.gov.au/ramsar/wet_report.html?listitem=53&mapimage='').

The Narran Lakes system is recognised as one of the most important waterbird habitats in Eastern Australia. Thoms et al (2001) report that 65 species of water birds have been recorded in the Narran Lakes, 46 of which breed in the system. Five species are listed under the NSW Threatened species Act (1995) and a further 8 species are of conservation concern.

Preliminary studies by New South Wales NPWS indicate that bird breeding in the Narran Lakes occurs when the system is 86% of capacity. Recruitment must occur sufficiently often to match the birds' life cycle. The vegetation of the Narran Lakes Nature Reserve is dominated by arid and semi-arid adapted species. Species richness is relatively high compared to other western reserves. Associated with the wetlands are a number of vegetation communities considered to be ecologically significant including: sedges and ephemeral herbfields, lignum, Phragmites and open riparian forests of Redgum, Coolibah, Black Box, and River Cooba. These communities are sensitive to frequency of inundation and other hydrological parameters. The Lignum shrublands in the Narran Lakes Complex are some of the largest undisturbed communities of their type in NSW.

There is limited information on the fish community of the Narran Lake System. A single study reports 5 native species, including high abundance of juvenile golden perch.

Appendix C. Abbreviations

AUSRIVAS	Australian River Assessment Scheme, an approach to assessing river health based on invertebrate populations and physical factors
CRCFE	Cooperative Research Centre for Freshwater Ecology
CRG	The Community Reference Group, formed to represent the stakeholders of the Lower Balonne as part of the Review
DST	A Decision Support Tool developed by SMEC (a consulting firm) to evaluate the impact of bunding levees on the floodplain of the Lower Balonne
IQQM	Integrated Quantity and Quality Model, a software tool used to evaluate various water management scenarios in the Condamine-Balonne catchment
LB, Lower Balonne	Lower Balonne River, downstream of St George
GL	Gigalitres, or 10^9 litres (a volume unit)
MAF	Mean Annual Flow
MDB	Murray-Darling Basin
MDBC	Murray-Darling Basin Commission
ML/day	Megalitres per day, or 10^6 litres per day (a unit of flow-rate)
NRM	Department of Natural Resources and Mines (Queensland)
PSM	Pells Sullivan Meynink (Brisbane), a consulting firm who carried out a major review of the hydrology of the Condamine-Balonne Draft Water Allocation and Management Plan (WAMP). Their final report is dated May 2001.
SKM	Sinclair Knight Merz, a consulting firm who have carried out several studies for stakeholders in the Lower Balonne
WAMP	Water Allocation Management Plan

Appendix D. Members of the Community Reference Group

Leith Boully (Chair)
John Barrett
Paul Brimblecombe
David Carson
Lenease Coopers
Ian Todd
John Grabbe
Jenny Guice
Simon Hall
Bill Hagarty
Ian Johnson
Richard Lomman
Sarah Moles
Wulf Reichler
Ronny Waters